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Volume 7, Number 4 April 1966

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Division of Radiological Health by Federal agencies, State health departments, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators. These are subject to review by a Board of Editorial Advisors with representatives from the following Federal agencies:

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RADIOLOGICAL HEALTH DATA AND REPORTS

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

SYNOPSES

Synopses of reports are presented below in reference card format for the reader's convenience.

FALLOUT FROM CHINESE NUCLEAR TEST OF MAY 13, 1965. *S. Gold, J. Hardin, E. Tabor, H. Krieger, B. Branson,* and *B. Kahn* (U.S. Public Health Service). *Radiological Health Data and Reports, Vol. 7, April 1966,* pp. 209–214.

Daily air sampling activities by the National Air Sampling Network in the latter part of May 1965 indicated the arrival of fallout attributed to the second atmospheric nuclear test by the mainland Chinese. Recently formed fallout was first detected in 24-hour samples of airborne particulates collected May 19–20, 1965, by the Helena, Montana, station. The highest gross beta activity found during the month was 7 pCi/m^3 at Denver, Colorado, on May 21–22. The major gamma-emitting radionuclides in the Denver samples were neptunium–239, molybdenum–99, and tellurium–132. Samples from other cities counted a week later than those from Denver contained predominantly barium–140, iodine–131, zirconium–niobium–95, cerium–141, and ruthenium–103.

Barium–140 detection in Cincinnati on May 21–22, and in New York on May 22–23, was noted in relation to the predicted arrival of fallout in the troposphere on May 19. Analyses of rain samples for barium–140 indicated deposition of fresh fallout by almost all rains occurring between May 22 and July 8.

KEY WORDS: Air, barium–140, cerium–141, China, fallout, fission products, gamma emitters, iodine–131, molybdenum–99, neptunium–239, niobium–95, nuclear test, radionuclides, rain, ruthenium–106, tellurium–132, zirconium–95.

COMPARISON OF STRONTIUM–90, IODINE–131, AND CESIUM–137 IN MILK AND MILK PRODUCTS. *T. C. Reavey* and *E. J. Baratta* (Division of Radiological Health). *Radiological Health Data and Reports, Vol. 7, April 1966,* pp. 215–218.

Distribution of strontium–90, iodine–131, and cesium–137 in series of whole milk and products representing the original milk in each series was studied. The radionuclide most affected by processing was iodine–131, which in the preparation of evaporated skim milk and nonfat dry milk was reduced to as little as 30 percent and 8 percent of the original fluid milk iodine–131 contents, respectively. While strontium–90 and cesium–137 contents of milk and milk products did not appear markedly changed by processing, cottage cheese, heavy cream, and butter retained the smallest concentrations of these radionuclides.

KEY WORDS: butter; buttermilk; cesium–137; cottage cheese; cream; dry milk; iodine–131; milk; skim milk; strontium–90.

Reports

FALLOUT FROM CHINESE NUCLEAR TEST OF MAY 14, 1965

S. Gold, J. Hardin, E. Tabor, H. Kreiger, B. Branson, and B. Kahn[1]

SYNOPSIS—Daily air sampling activities by the National Air Sampling Network in the latter part of May 1965 indicated the arrival of fallout attributed to the second atmospheric nuclear test by the mainland Chinese. Recently formed fallout was first detected in 24-hour samples of airborne particulates collected May 19–20, 1965, by the Helena, Montana, station. The highest gross beta activity found during the month was 7 pCi/m³ at Denver, Colorado, on May 21–22. The major gamma-emitting radionuclides in the Denver samples were neptunium–239, molybdenum–99, and tellurium–132. Samples from other cities counted a week later than those from Denver contained predominantly barium–140, iodine–131, zirconium-niobium–95, cerium–141, and ruthenium–103.

Barium–140 detection in Cincinnati on May 21–22, and in New York on May 22–23, was noted in relation to the predicted arrival of fallout in the troposphere on May 19. Analyses of rain samples for barium–140 indicated deposition of fresh fallout by almost all rains occurring between May 22 and July 8, 1965.

In anticipation of fallout from the second atmospheric nuclear test by the mainland Chinese on May 14, 1965 (2 a.m. Greenwich time, May 14, or 10 p.m. EST, May 13), airborne particulate samples were collected daily from May 20–27 at the National Air Sampling Network (NASN) stations shown in figure 1, and at the Radiological Health Research Activities (RHRA) station in Cincinnati. On May 28, all of the NASN stations shown in figure 2 collected their regular biweekly air samples and submitted them for analysis. The arrival in the United States of fallout from this nuclear test was thus detected at ground level by the NASN and its magnitude estimated in support of radiation surveillance of the air by the Radiation Surveillance Network (RSN) (*1*).

At each station, suspended particulate matter from approximately 2,500 cubic meters of air was collected with a high-volume pump on an 8- by 10-inch glass fiber filter over a 24-hour period. After collection, the filters were removed and sent to the Robert A. Taft Sanitary Engineering Center for analysis. Gross beta activity from fallout was measured with an end-window proportional counter after the decay of the short-lived radioactive daughters of naturally occurring radon and thoron, 4 days after collection. The radioactivity concentration in picocuries per cubic meter of air was determined by:

$$A = \frac{KC}{FEV}$$

where: A = concentration (pCi/m³)
K = 2.22 (pCi/dpm)
C = count rate (cpm)
F = self-absorption factor
E = counter efficiency (cpm/dpm)
V = air volume (m³)

[1] Messrs. Gold, Hardin, Kreiger, and Branson are staff members, and Dr. Kahn is chief, Radiological Health Research Activities, Division of Radiological Health; Dr. Tabor is chief, National Air Sampling Network, Laboratory of Engineering and Physical Sciences, Division of Air Pollution. Both of these Divisions are agencies of the Public Health Service, U.S. Department of Health, Education, and Welfare, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio.

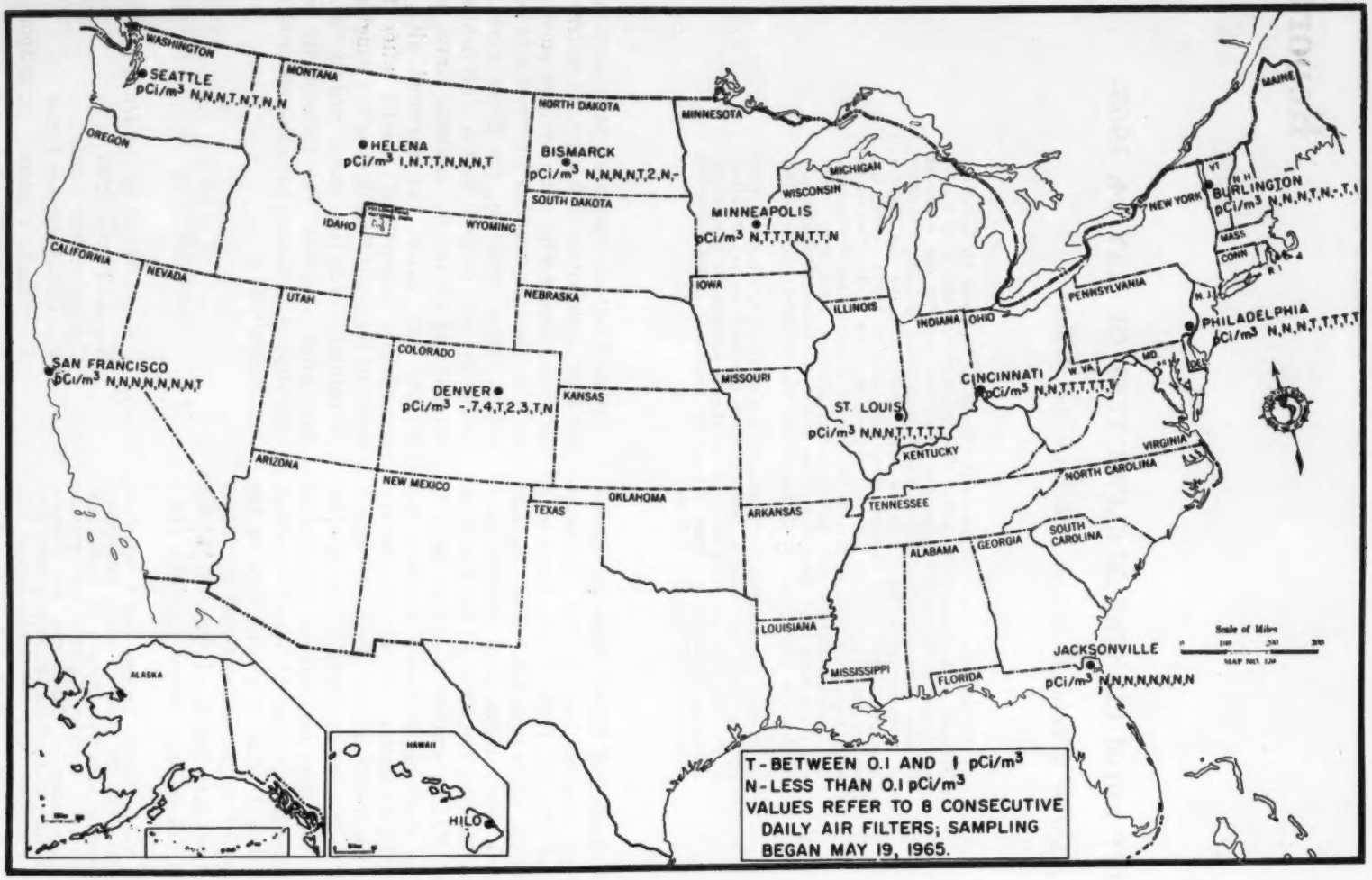

Figure 1. Recently formed fallout on airborne particles NASN stations and RHRA station (using glass fiber filters with air volume of approximately 2,500 m³)

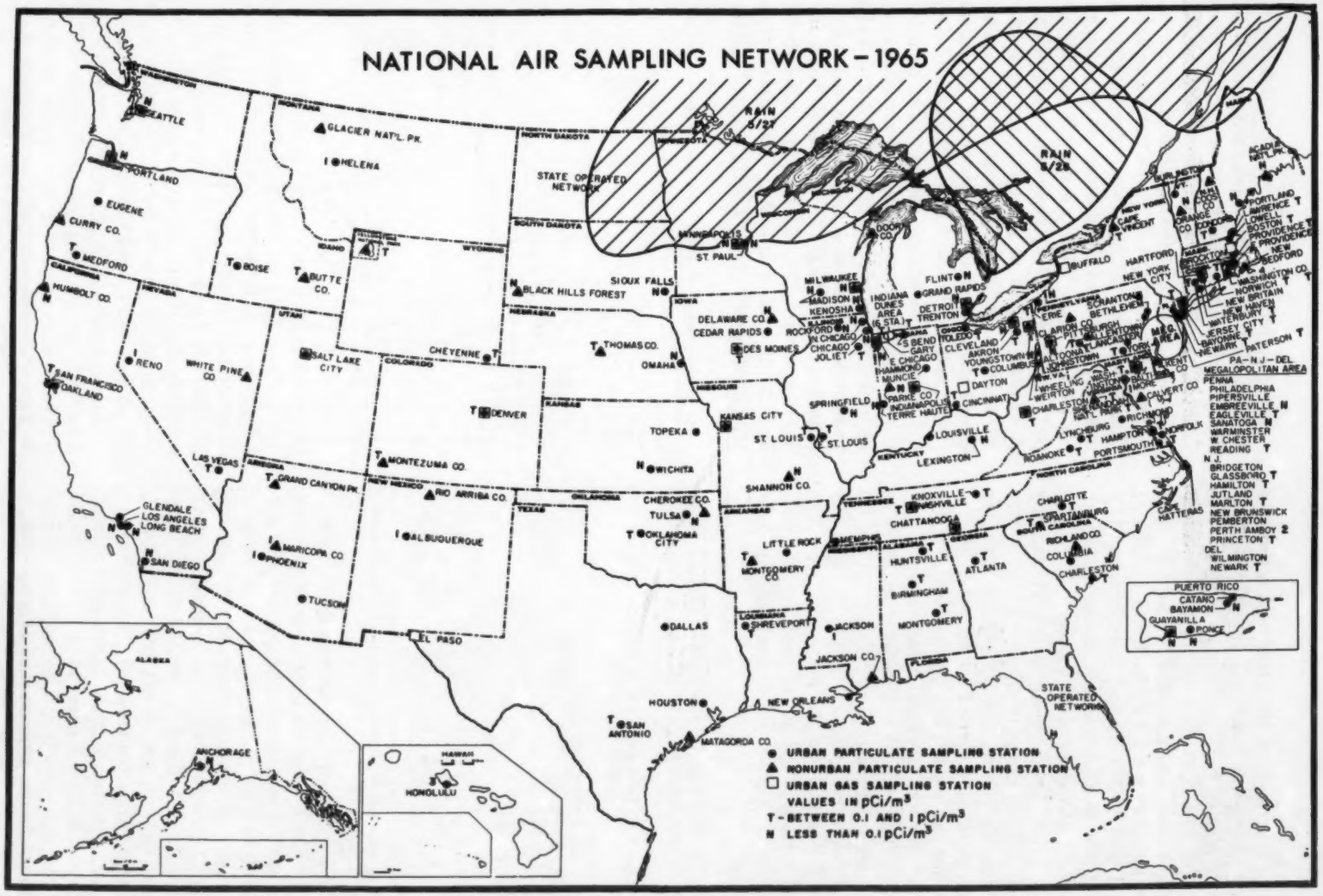

Figure 2. Recently formed fallout on airborne particles collected May 27–28, 1965

After several days, the gross beta activity of the air filters was measured again to identify recently formed radionuclides by a decrease in the count rate. Gamma-emitting radionuclides were identified and measured by gamma spectral analysis with a 4- by 4-inch NaI (thallium) crystal and a 200-channel spectrometer (*2*). Errors due to counting are approximately ± 10 percent of the reported values.

The gross beta concentration of recently formed fallout given in figures 1 and 2 was estimated by subtracting 0.5 pCi/m³ from the measured value to correct for fallout from previous nuclear tests. (The concentration of 0.5 pCi/m³ was the average measured in April, when no fresh fallout was detected on airborne particules.) Concentrations between 1.0 and 0.1 pCi/m³ were recorded as trace (T), and any below 0.1 pCi/m³ as not detectable (N). The values pertain to the day of counting and were undoubtedly higher when the samples were collected.

Recently formed fallout was first detected at Helena, Montana, on the first day of collection, May 19–20. The highest gross beta activity was 7 pCi/m³ at Denver, Colorado, on May 21–22; the RSN also reported maximum concentrations in this area (*1*). Figures 1 and 2 indicate that short-lived radionuclides were detected in most parts of the United States during the latter part of May. With few exceptions, concentrations on May 27–28 were below 1.0 pCi/m³. A similar pattern of arrival from the Northwest and distribution throughout the United States within a week was observed for fallout from the first Chinese test in October 1965 (*3*).

The gamma-emitting radionuclides collected in some of the more radioactive air filters are identified in the spectra of figures 3 and 4 and quantitated in tables 1 and 2. The major constituents of the filters from Denver were 2.3-day neptunium–239, 2.8-day molybdenum–99, and 3.2-day tellurium–132. The filters from the cities listed in table 2 were counted a week

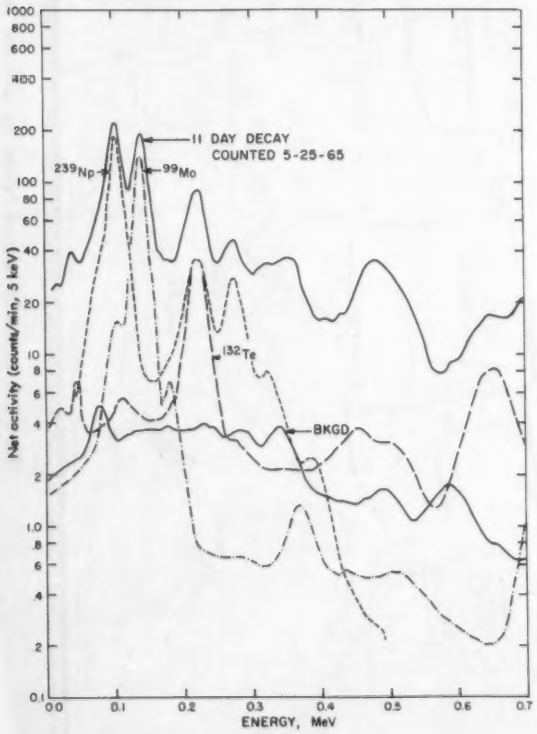

Figure 3. Gamma spectrum of air filter collected May 20, 1965, at Denver, Colorado

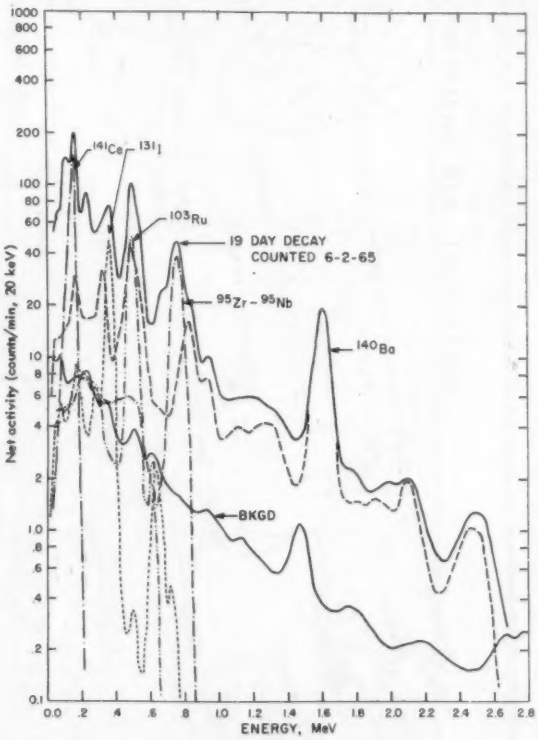

Figure 4. Gamma spectrum of air filter collected May 27, 1965, at Honolulu, Hawaii

Table 1. Short-lived gamma-emitting radionuclides on airborne particles at Denver, Colorado

Radionuclide	Half-life (days)	Expected percent of gross beta activity, 10-day-old mixture (4)	Concentration at collection, pCi/m³	
			5/20/65 [a]	5/21/65
Gross beta [b]		100	6.5	2.9
Neptunium-239	2.3	—	7.1 [c] (—)	3.4 [c] (—)
Molybdenum-99	2.8	8.2	2.4 (14)	0.80 (13)
Tellurium-132	3.2	6.1	0.98 (6.3)	0.49 (8.8)
Barium-140	12.8	11.8	0.66 (8.2)	0.32 (9.4)
Iodine-131	8.1	7.3	0.50 (5.4)	0.20 (5.3)
Zirconium-niobium-95	65	4.4	0.60 (9.2)	0.18 (6.2)
Cerium-141	33	6.4	0.52 (7.4)	0.22 (7.2)
Ruthenium-103	40	3.2	0.15 (2.2)	0.074 (2.4)

[a] 24-hour collection period ending on this day.
[b] Recently formed fission products only, on 5/24/65.
[c] Figures in parentheses are percent of gross beta activity after correction for decay to 5/24/65.

Table 2. Short-lived gamma-emitting radionuclides on airborne particles at Honolulu, Tucson, and Cincinnati

Radionuclide	Half-life (days)	Expected percent of gross beta activity, 20-day-old mixture	Concentration at collection, pCi/m³		
			Honolulu 5/27–28/65 [a]	Tucson 5/29–30/65 [b]	Cincinnati 5/23–24/65 [b]
Gross beta [b]		100	2.3	8.3	0.80
Barium-140	12.8	12.3	0.46 [c] (14)	1.4 (13)	0.17 (12)
Iodine-131	8.1	5.6	0.23 (6.1)	0.70 (5.9)	0.089 (4.8)
Zirconium-niobium-95	65	8.3	0.22 (9.6)	0.53 (6.4)	0.063 (7.9)
Cerium-141	33	9.5	0.31 (12)	1.1 (12)	0.12 (12)
Ruthenium-103	40	4.7	0.19 (7.3)	0.65 (7.3)	0.059 (6.1)

[a] 24-hour collection period ending on this day.
[b] Recently-formed fission products only, on 6/3/65.
[c] Figures in parentheses are percent of gross beta activity after correction for decay to 5/24/65.

later than those from Denver; they contained predominantly barium–140, iodine–131, zirconium-niobium–95, cerium–141, and ruthenium–103, although the shorter-lived neptunium–239, molybdenum–99, and tellurium–132 were still present. Radionuclides with half-lives longer than that of 40-day ruthenium–103 from this and previous tests were obscured in these spectra by the indicated radionuclides.

The short-lived radionuclides are all fission products except for neptunium–239, which is the daughter of 23.5-minute uranium–239, formed by the (n,γ) reaction with uranium–238. The fission product distribution approximates the distribution based on reported yields (4). Table 1 shows some fractionation, as in the higher concentrations of molybdenum–99 and zirconium-niobium–95.

To compute these values, the concentrations at the time of counting were extrapolated to the collection date. For the gross beta concentration of fresh fission products, the concentrations of old fallout (0.5 pCi/m³) and of neptunium–239 were subtracted, and the activity was then extrapolated for logarithmic decay.

The iodine–131 values given in tables 1 and 2 may be lower than actual iodine–131 concentrations in air, because a fraction of the radionuclide was gaseous rather than associated with airborne particles (5). As shown in table 3, some iodine–131 passed through the glass-fiber filter and was collected on charcoal. If the charcoal retained all of the iodine–131 that passed into the cartridge, and the relative concentrations on the filter and the charcoal were typical, one-third to one-half of the iodine–131 in the air was not collected on filters.

Table 3. Iodine-131 in ground-level air, Cincinnati, Ohio, May 1965

Collection date, 1965	Gross beta concentration 4 days after collection (pCi/m³)		Concentration at collection (pCi/m³)	
	Old	Fresh	Iodine-131 filter	Iodine-131 cartridge [a]
5/14–17	0.54	<0.1	<0.01	<0.005
5/17–20	0.36	<0.1	<0.01	<0.005
5/20–24	0.31	0.42	0.045	0.023
5/24–28	0.22	0.43	0.034	0.031
5/28–6/1	0.53	<0.1	<0.02	0.012

[a] 8-cm diameter, 2.5-cm depth, containing 85 gram charcoal; linear flow rate was 2 m/sec.

Short-lived gamma-emitting radionuclides at gross beta concentrations below 1 pCi/m³ were not so easily identifiable as those for the higher concentrations shown in figures 3 or 4, but the spectra of the mixture were distinguishable from old fallout, as shown in figure 5. The most sensitive indicator of fresh fallout was the 1.60–MeV peak of the lanthanum–140 daughter of barium–140. Consecutive daily concentrations of barium–140 at Cincinnati (table 4) show the arrival of fresh fallout on May 21–22 and its detection on almost every day until July 7–8. In addition to the daily variations in barium–140 concentration because of changes in

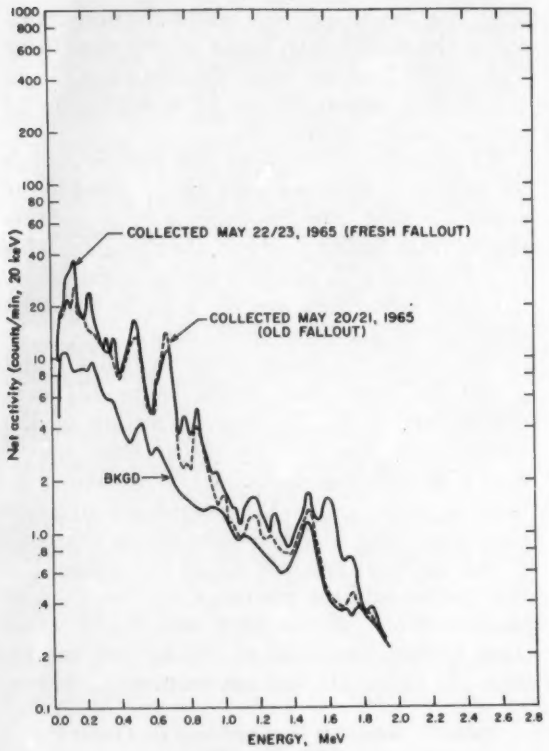

Figure 5. Gamma spectra of air filters collected at Cincinnati, Ohio, showing old and recently formed fission products

the weather, three broad peaks appeared, with maxima on approximately May 24, June 9, and June 22. The 2-week periods separating these maxima may be the time required for the fallout cloud to circle the globe. The initial detection on May 21–22 compares with the first appearance of barium-140 in New York on May 22–23, and the predicted arrival in the troposphere on May 19 (*5*).

Almost all of the rains occurring between May 22 and July 8 deposited fresh fallout on Cincinnati, as indicated by their barium-140 contents, listed in table 4. The deposition of this fresh fallout led to detectable iodine-131 concentrations in milk from this area during the period (*6*).

Table 4. Barium-140 on airborne particles and in rain at Cincinnati, Ohio

Date 1965 [a]	Air, (pCi/m³) [b]	Rain, (pCi/liter)[b] (mm)	Date 1965 [a]	Air (pCi/m³) [b]	Rain (pCi/liter)[b] (mm)
May 20	<0.01		June 17	0.04	
21	<0.01		18	0.07	
22	0.03		19	0.09	
23	0.11		20	0.07	
24	0.17		21	0.10	
25	0.05	450 (2)	22	0.14	
26	Lost	80 (2)	23	0.13	
27	0.07		24	0.09	<10 (1)
28	0.08		25	0.07	
29	0.03		26	0.05	
30	<0.01		27	0.07	
31 [c]			28	0.04	
June 1 [c]	0.02	85 (2)	29	0.01	<10 (24)
2	0.06	75 (10)	30	0.02	
3	0.10		July 1	0.05	
4	0.01		2	0.06	10 (1)
5	0.06		3	0.04	
6	0.16	70 (15)	4	0.03	10 (4)
7	0.11		5 [c]		
8	0.16	60 (1)	6 [c]	0.03	
9	0.20		7	0.03	10 (2)
10	0.10	70 (1)	8	0.01	
11	0.09	55 (10)	9	<0.01	
12	0.08		10	<0.01	<10 (19)
13	0.06		11	<0.01	
14	0.06		12	<0.01	
15	0.02		13	<0.01	
16	0.04		14	<0.01	<10 (5)

[a] 24-hour collection period ending on this date.
[b] Corrected for decay to date of collection. Numbers in parentheses give mm of rainfall.
[c] 48-hour collection period.

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COMPARISON OF STRONTIUM-90, IODINE-131, AND CESIUM-137 IN MILK AND MILK PRODUCTS

Thomas C. Reavey and Edmond J. Baratta[1]

SYNOPSIS—Distribution of strontium–90, iodine–131, and cesium–137 in series of whole milk and products representing the original milk in each series was studied. The radionuclide most affected by processing was iodine–131, which in the preparation of evaporated skim milk and nonfat dry milk was reduced to as little as 30 percent and 8 percent of the original fluid milk iodine–131 contents, respectively. While strontium–90 and cesium–137 contents of milk and milk products did not appear markedly changed by processing, cottage cheese, heavy cream, and butter retained the smallest concentrations of these radionuclides.

A study of the levels of strontium–90, iodine–131, and cesium–137 in samples of whole milk and milk products obtained from two local processing plants serving the Boston area was conducted by the staff of the Northeastern Radiological Health Laboratory during 1962, 1963, 1964, and reported previously (*1*).

For iodine–131 comparison, four groups of samples were collected from two milk plants. The first of these groups, obtained during a period of elevated local fallout, included heavy cream, whole milk, evaporated skim milk (40 percent milk solids), and nonfat dry milk. For evaluation of strontium–90 and cesium–137, three series of samples were obtained, at one month intervals, from a second plant. These included fluid milk and six different milk products. Product samples in each group were selected to be representative of the original fluid milk.

Iodine–131 distribution

The distribution of iodine–131 in the four groups of samples is shown in table 1. The measured concentrations of iodine–131 in samples of each product are listed in the second column of table 1. The data in the table are divided into four groups. The samples within each group were collected so that the activities of the samples from one group are comparable. All iodine–131 concentrations are corrected for decay to the time of collection. However, the activities of samples from one group cannot be compared to the activities from another. For example, the activities of the heavy cream sample and the whole milk sample in Group A, table 1, can be used to determine the iodine–131 carried over from the whole milk into the cream sample. However, the activity of the heavy cream sample of Group B cannot be compared to the activity of the whole milk sample of Group A. Based on the data in table 1, the relative amount of iodine–131 in each product as contrasted to the original whole milk is shown in figure 1. This figure was constructed on the basis of an assumption that the percentage distribution of activity for each of the products will be approximately the same, regardless of the activity in the original milk sample. This assumption is roughly

Table 1. Concentrations of iodine-131 in samples of milk and milk products

Group	Product	Percent of original weight	Observed ^{131}I concentration (pCi/kg)[a,b]
A	Whole milk	100	261
	Evaporated skim milk (40 percent milk solids)	20	322
	Heavy cream (40 percent butterfat)	10	493
	Nonfat dry milk	8	228
B	Heavy cream	10	46
	Butter	5	16
	Buttermilk concentrate	1.7	200
C	Skim milk	90	82
	Cottage cheese[c]	14	31
D	Whole milk	100	81
	Skim milk	90	70

[a] Corrected for decay to time of collection.
[b] Although the analytical errors for measurements of this kind may be expected to be on the order of those reported for various milk networks, these are not presented here since normal variations in the composition of milk could outweigh the analytical error.
[c] Not creamed.

[1] Mr. Reavey is a staff chemist and Mr. Baratta is director, Analytical Services Program, Northeastern Radiological Health Laboratory, Winchester, Massachusetts.

borne out by the relationships shown in the analytical data. Observation of the data shows that heavy cream (40 percent butterfat) contained almost twice as much iodine–131 per kilogram as whole milk. However, since heavy cream represents only about 10 percent of the weight of the whole milk, the total content of iodine–131 in the cream was only about 20 percent of that in the milk.

The concentration of iodine–131 in evaporated skim milk (a concentrate containing 40 percent milk solids[2]) was about 25 percent greater than that in the original whole milk. Due to the weight loss by evaporation, this concentration of iodine–131 actually represents only about 30 percent of the activity in the original sample (figure 1). This indicates a direct loss of iodine–131 in the evaporation process. Continued evaporation in the process of producing nonfat dry milk, reduced the iodine–131 content still further. This loss was confirmed by the fact that only 8 percent of the iodine–131 in the original whole milk was retained in a non-fat dry milk. Raymond and Williams (*2*) reported a 40 percent loss of iodine–131 in the production of nonfat dry milk and no loss in the production of evaporated milk. This discrepancy may be accounted for by differences in manufacturing processes.

[2] Referred to as "number three condensed milk" in the industry.

Strontium–90 and cesium–137 distribution

The concentration of strontium–90 and cesium–137 in the three series of samples obtained from the second plant are shown in table 2. Calculated ratios of strontium–90 to stable calcium, and cesium–137 to stable potassium are also tabulated. As in table 1, the data of samples within a group of any one series are comparable, but data from different groups and series are not comparable. Using the same assumption as for figure 1, the relative amounts of strontium–90 in each product, as contrasted to that in the original whole milk, are shown in figure 2.

The data indicate that very small percentages of strontium–90 were retained in heavy cream, butter, and cottage cheese, as compared to the amount in the original whole milk. However, the strontium–90 to calcium ratios were essentially constant within each series of samples, indicating that strontium–90 accompanies calcium in each of the separation processes.

The distribution of cesium–137 was similar to that of strontium–90 (figure 3). The products in which the cesium–137 concentration is low are also low in stable potassium. Thus it may be concluded that cesium–137 closely follows potassium in each of the separation processes. These results and those on strontium–90 are in substantial agreement with other authors (*3–7*).

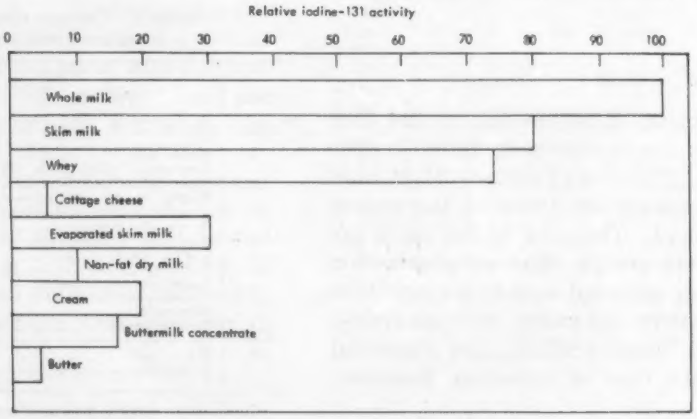

Figure 1. Distribution of iodine–131 in milk and milk products

Table 2. Strontium-90 to calcium and cesium-137 to potassium ratios in samples of milk and milk products [a]

Product	Series	^{90}Sr (pCi/kg)	Ca (g/kg)	Ratio of ^{90}Sr to Ca (pCi/g)	^{137}Cs (pCi/kg)	K (g/kg)	Ratio of ^{137}Cs to K (pCi/g)
Group 1							
Whole milk	A	38.1	1.13	34	296	1.45	204
	B	33.4	1.15	29	342	1.32	259
	C	23.0	1.13	20	227	1.33	171
Heavy cream	A	21.8	0.65	34	210	1.14	184
	B	16.8	0.58	29	167	1.04	161
	C	10.7	0.48	22	149	0.88	169
Non-fat dry milk	A	460	13.2	35	3,535	17.4	203
	B	380	13.7	28	3,268	17.8	184
	C	386	18.8	21	3,396	18.4	185
Group 2							
Skim milk	A	42.5	1.26	34	348	1.50	232
	B	50.0	1.25	40	378	1.60	236
	C	45.7	1.28	36	348	1.52	229
Large curd (cottage cheese)	A	21.2	0.60	35	104	0.39	267
	B	23.6	0.55	43	110	0.39	282
	C	20.6	0.52	40	101	0.38	266
Small curd (cottage cheese)	A	10.4	0.22	48	44	0.13	338
	B	16.7	0.39	43	128	0.40	320
	C	7.9	0.26	30	56	0.29	193
Whey	A	50.1	1.28	39	358	1.60	224
	B	54.8	1.27	43	399	1.72	232
	C	46.2	1.31	35	362	1.59	228
Group 3							
Heavy cream	A	17.1	0.57	30	162	0.89	182
	B	16.4	0.56	29	174	0.90	192
	C	16.5	0.59	28	216	0.96	225
Butter	A	—	0.09	—	38	0.22	173
	B	4.7	0.09	52	38	0.15	253
	C	4.2	0.14	29	80	0.27	296

[a] See footnote b, table 1.

Discussion

The processes involved in the production of certain milk products can cause a significant reduction in their iodine–131 content. This is well demonstrated by the data for evaporated skim milk (40 percent milk solids) and nonfat dry milk, from which portions of the respective radioactive contents were lost during the evaporation process. If no iodine–131 had been lost, the evaporated skim milk would have contained about 1,000 picocuries of iodine–131 per kilogram. Since nonfat dry milk represents only 8 percent of the weight of the original whole milk, and liquid skim milk contains 80 percent of the iodine–131 in whole milk, the dry product would have contained about ten times as much iodine–131 per kilogram as the original milk, had there been no losses in the evaporation process. In this study, however, the measured iodine–131 activity of

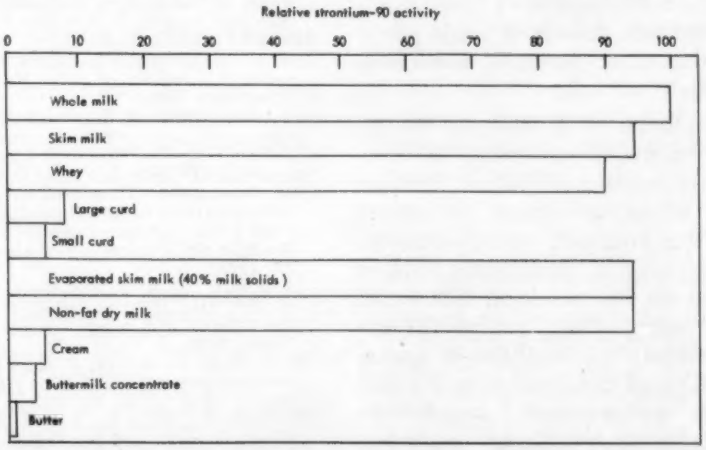

Figure 2. Distribution of strontium–90 in milk and milk products

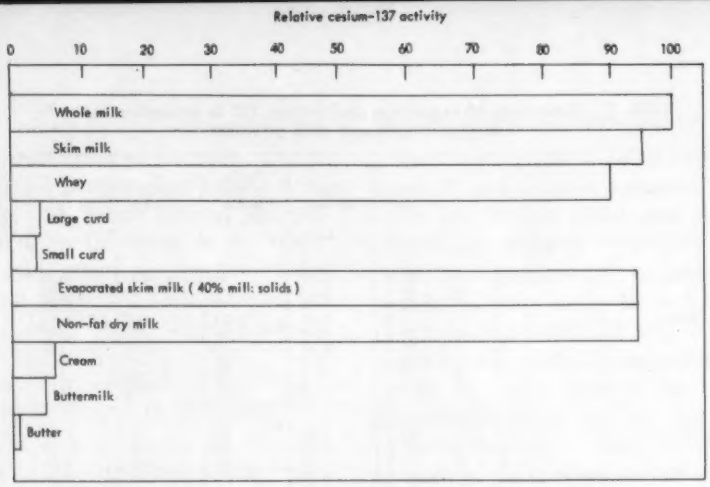

Figure 3. Distribution of cesium–137 in milk and milk products

the evaporated skim milk samples (table 1) was roughly equal to that of the skim milk. Based on these results, conversion of contaminated whole milk into evaporated skim milk or non-fat dry milk could be one means for reducing iodine–131 levels in times of emergency.

Since the ratio of strontium–90 to stable calcium remained almost constant in the fluid milk and its various products, it is apparent that the processes involved in their manufacture did not in any way cause a preferential loss of strontium–90. The data show that cottage cheese (small curd), heavy cream, and butter represent the products with the lesser concentrations of calcium and hence of strontium–90. In times of emergency, milk contaminated with higher levels of strontium–90 could be directed to the manufacture of these products. It is asumed that strontium levels would not be so high that these products would also be health hazards.

From the standpoint of protein or energy (calorie) requirements, Lengemann (*3*) has shown that dietary needs could be met through the substitution of cottage cheese for whole milk. Although this approach would considerably reduce the intake of strontium–90, it is important to note that the resulting diet would be inadequate in calcium. Since cesium–137 appears to follow closely the behavior of strontium–90, the amount of radiocesium in the diet would likewise be reduced if such a substitution were made. Because of the dietary need for calcium and the greater health hazard of strontium–90, however, it would appear that, in times of emergency, the utilization of milk products should be based on the intake of calcium and strontium–90 rather than cesium–137.

Acknowledgement

The authors wish to acknowledge the assistance of Miss B. Lucile Bridges, executive director, New England Dairy and Food Council, for guidance in planning this study; and to Dr. Harry L. Wildasin, laboratory director, H. P. Hood and Sons; and Mr. Oscar Hall, plant manager, New England Milk Producers Association, for their help in collecting the samples.

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Section I. Milk and Food

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Efforts are being made by both Federal and State agencies to monitor the intake of various radionuclides in the total diet on a continuing basis. Although the total diet is the most direct measure of intake of radionuclides, indicator foods may be used to estimate dietary intake where specific dietary data are not available. As fresh milk is consumed by a large segment of the United States population and contains most of the biologically significant radionuclides from nuclear test debris which appear in the diet, it is the single food item most often used as an indicator of the population's intake. Moreover, it is the major source of dietary intake of shortlived radionuclides. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of milk. More direct estimates of dietary intake of radionuclides than those furnished by indicator foods can be obtained by analyses of the total diet or representative principal food items or groups combined with appropriate consumption data.

The Federal Radiation Council has developed Radiation Protection Guides (RPG's) for controlling normal peacetime operations, assuming continuous exposure from intake by the population at large (*1*, *2*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the International Commission on Radiological Protection (*4*,*5*).

Data from selected National, International, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross section of routine sampling programs which may be considered of a continuing nature.

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NATIONAL AND INTERNATIONAL MILK SURVEILLANCE

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various National and International organizations routinely monitor radionuclide levels in milk. In addition to those programs reported below, *Radiological Health Data and Reports* coverage includes:

Program	Period reported	Last presented
Radiostrontium in milk	January–March 1965	September 1965
United Kingdom milk	January 1961–April 1962	October 1962

1. Pasteurized Milk Network December 1965

Division of Radiological Health and Division of Environmental Engineering and Food Protection, PHS

The Public Health Service's Pasteurized Milk Network (PMN) was designated to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 sampling stations (figure 1) provides data on milk in every State. In addition, milk is sampled in the Canal Zone and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the PMN appeared in the December 1965 *Radiological Health Data* (*1*).

The results for December 1965 and fourth

Figure 1. Pasteurized Milk Network sampling locations

Table 1. Average concentrations of stable elements and radionuclides in pasteurized milk for the fourth quarter and December 1965[a]

Sampling locations		Calcium (g/liter)		Strontium-89 (pCi/liter)		Strontium-90 (pCi/liter)		Cesium-137 (pCi/liter)		Iodine-131 (pCi/liter)	
		Fourth quarter	December 1965	Fourth quarter	December 1965	Fourth quarter	December 1965	Fourth quarter	December 1965	Fourth quarter	December 1965
Ala:	Montgomery	1.18	1.21	<5	<5	14	12	30	30	0	0
Alaska:	Palmer	1.30	1.23	<5	<5	15	20	55	70	0	0
Ariz:	Phoenix	1.25	1.26	<5	<5	4	3	15	15	0	0
Ark:	Little Rock	1.20	1.22	<5	<5	27	26	30	35	0	0
Calif:	Sacramento	1.27	1.30	<5	<5	4	4	15	20	0	0
	San Francisco	1.29	1.32	<5	<5	4	4	15	20	0	0
C. Z:	Cristobal	1.13	1.13	<5	<5	5	5	35	30	0	0
Colo:	Denver	1.28	1.28	<5	<5	12	12	25	35	0	0
Conn:	Hartford	1.12	1.12	<5	<5	12	11	40	40	0	0
Del:	Wilmington	1.15	1.18	<5	<5	14	14	35	35	0	0
D. C:	Washington	1.16	1.16	<5	<5	13	13	25	30	0	0
Fla:	Tampa	1.18	1.22	<5	<5	14	12	135	110	0	0
Ga:	Atlanta	1.17	1.19	<5	<5	19	20	45	40	0	0
Hawaii:	Honolulu	1.16	1.17	<5	<5	6	4	40	40	0	0
Idaho:	Idaho Falls	1.28	1.30	<5	<5	13	13	45	50	0	0
Ill:	Chicago	1.14	1.14	<5	<5	11	10	35	40	0	0
Ind:	Indianapolis	1.17	1.17	<5	<5	12	12	25	25	0	0
Iowa:	Des Moines	1.26	1.26	<5	<5	14	12	20	25	0	0
Kans:	Wichita	1.27	1.31	<5	<5	13	13	20	25	0	0
Ky:	Louisville	1.16	1.19	<5	<5	17	16	20	20	0	0
La:	New Orleans	1.22	1.23	<5	<5	30	29	40	40	0	0
Maine:	Portland	1.14	1.16	<5	<5	17	17	65	70	0	0
Md:	Baltimore	1.17	1.20	<5	<5	16	17	25	25	0	0
Mass:	Boston	1.15	1.17	<5	<5	16	15	60	60	0	0
Mich:	Detroit	1.12	1.12	<5	<5	11	10	30	30	0	0
	Grand Rapids	1.16	1.16	<5	<5	14	13	45	50	0	0
Minn:	Minneapolis	1.26	1.25	<5	<5	22	21	40	35	0	0
Miss:	Jackson	1.24	1.30	<5	<5	25	24	25	25	0	0
Mo:	Kansas City	1.22	1.23	<5	<5	16	14	20	20	0	0
	St. Louis	1.27	1.27	<5	<5	18	16	20	20	0	0
Mont:	Helena	1.31	1.34	<5	<5	15	16	45	50	0	0
Nebr:	Omaha	1.22	1.21	<5	<5	16	13	25	25	0	0
Nev:	Las Vegas	1.27	1.28	<5	<5	5	6	25	25	0	0
N. H:	Manchester	1.14	1.15	<5	<5	18	18	70	75	0	0
N. J:	Trenton	1.14	1.15	<5	<5	11	12	30	35	0	0
N. Mex:	Albuquerque	1.23	1.25	<5	<5	6	7	20	25	0	0
N. Y:	Buffalo	1.10	1.10	<5	<5	11	11	40	40	0	0
	New York	1.11	1.14	<5	<5	14	13	40	45	0	0
	Syracuse	1.10	1.11	<5	<5	12	12	35	40	0	0
N. C:	Charlotte	1.20	1.25	<5	<5	25	26	30	30	0	0
N. Dak:	Minot	1.27	1.25	<5	<5	30	28	40	50	0	0
Ohio	Cincinnati	1.15	1.16	<5	<5	13	11	20	25	0	0
	Cleveland	1.14	1.16	<5	<5	13	13	25	30	0	0
Okla:	Oklahoma City	1.17	1.18	<5	<5	14	13	20	20	0	0
Ore:	Portland	1.27	1.28	<5	<5	12	11	40	35	0	0
Pa:	Philadelphia	1.12	1.14	<5	<5	12	11	30	30	0	0
	Pittsburgh	1.13	1.11	<5	<5	17	17	40	45	0	0
P. R:	San Juan	1.11	1.11	<5	<5	9	9	30	25	0	0
R. I:	Providence	1.14	1.15	<5	<5	15	14	45	50	0	0
S. C:	Charleston	1.19	1.22	<5	<5	25	24	55	45	0	0
S. Dak:	Rapid City	1.23	1.29	<5	<5	21	20	45	45	0	0
Tenn:	Chattanooga	1.25	1.28	<5	<5	22	20	30	35	0	10
	Memphis	1.18	1.20	<5	<5	18	16	20	25	0	0
Tex:	Austin	1.17	1.20	<5	<5	6	6	10	10	0	0
	Dallas	1.17	1.20	<5	<5	12	11	20	20	0	0
Utah:	Salt Lake City	1.38	1.37	<5	<5	12	13	40	40	0	0
Vt:	Burlington	1.12	1.14	<5	<5	14	13	50	55	0	0
Va:	Norfolk	1.18	1.21	<5	<5	16	15	25	25	0	0
Wash:	Seattle	1.30	1.32	<5	<5	16	13	45	35	0	0
	Spokane	1.31	1.35	<5	<5	16	14	45	50	0	0
W. Va:	Charleston	1.16	1.16	<5	<5	16	15	20	20	0	0
Wis:	Milwaukee	1.20	1.20	<5	<5	12	11	40	40	0	0
Wyo.	Laramie	1.29	1.35	<5	<5	16	11	45	45	0	0
Network average		1.20	1.21	<5	<5	14.6	13.9	35	36	0	0

[a] All barium-lanthanum-140 values below detectable levels.

quarter of 1965 are presented in table 1. The average monthly radionuclide concentrations are based on results obtained from samples collected weekly. If radionuclide values were below minimum detectable concentrations (*1*), averages were calculated using one-half the minimum detectable value; however, for iodine–131 and barium–140, zero was used for averaging purposes when concentrations were below minimum detectable levels.

Table 2. Frequency distribution, strontium-90 concentrations in milk at Pasteurized Milk Network stations, July–December 1965 and December 1964

Strontium-90 (pCi/liter)	Number of stations						
	1965						1964
	July	Aug	Sept	Oct	Nov	Dec	Dec
Under 10	8	10	11	8	9	9	8
10–19	34	41	44	46	43	43	29
20–29	18	11	7	7	9	11	20
30–39	3	1	1	2	2	0	4
40–49	0	0	0	0	0	0	2

Table 3. Frequency distribution, cesium-137 concentrations in milk at Pasteurized Milk Network stations, July–December 1965 and December 1964

Cesium-137 (pCi/liter)	Number of stations						
	1965						1964
	July	Aug	Sept	Oct	Nov	Dec	Dec
Under 50	34	45	50	54	57	51	9
50–99	25	16	12	8	5	11	38
100–149	3	1	0	0	1	1	14
150–199	1	1	1	1	0	0	2

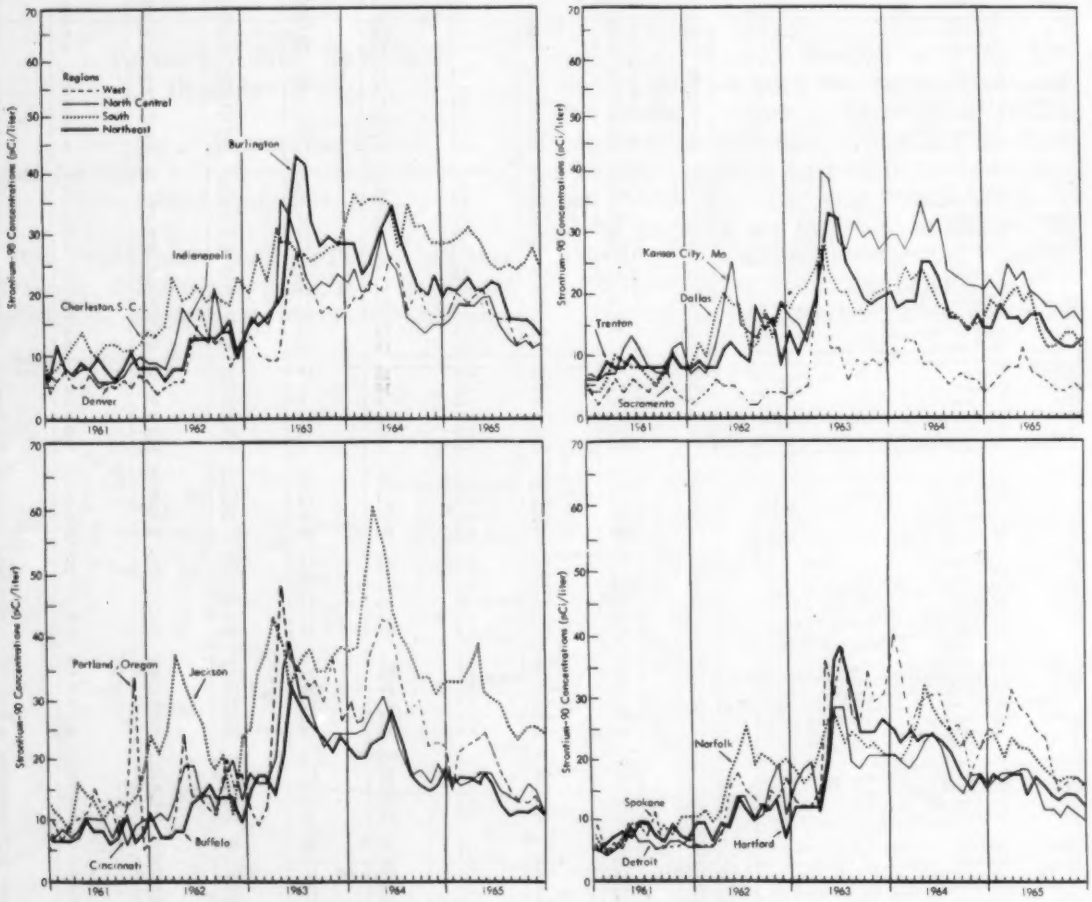

Figure 2. Strontium–90 concentrations in pasteurized milk, 1961—December 1965

Distributions of strontium–90 and cesium–137 are presented in tables 2 and 3 for July through December 1965; for comparative purposes corresponding values for December 1964 are also shown. The average strontium–90 concentrations in pasteurized milk from selected cities are presented in figure 2.

2. Canadian Milk Network December 1965[1]

Radiation Protection Division
Department of National Health and Welfare
Ottawa, Canada

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine–131, and monthly composites are analyzed for strontium–90, cesium–137, and stable calcium and potassium. The analytical procedures were outlined in the December 1965 issue of *Radiological Health Data* (*2*).

The December 1965 monthly average strontium–90, cesium–137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 4. Iodine–131 and strontium–89 concentrations were below minimum detectable levels.

Table 4. Stable elements and radionuclides in Canadian whole milk, December 1965

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.15	1.5	18.7	70
Edmonton	1.15	1.5	19.2	57
Ft. William	1.10	1.5	31.8	76
Fredericton	1.11	1.6	26.6	77
Halifax	1.14	1.6	23.3	70
Montreal	1.09	1.6	16.3	45
Ottawa	1.13	1.6	13.7	40
Quebec	1.08	1.6	26.9	87
Regina	1.11	1.6	15.0	40
St. John's, Nfld	1.01	1.4	24.8	89
Saskatoon	1.11	1.6	18.1	42
Sault Ste. Marie	1.11	1.5	30.6	79
Toronto	1.16	1.5	10.0	38
Vancouver	1.17	1.5	19.1	90
Windsor	1.12	1.6	9.5	29
Winnipeg	1.10	1.4	17.5	47
Average	1.12	1.5	20.1	61

[1] Prepared from January 1966 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

Figure 3. Canadian milk sampling stations

3. Pan American Milk Sampling Program December 1965

Pan American Health Organization, and Public Health Service

The Pan American Health Organization (PAHO), in collaboration with the Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

Under a joint agreement between both agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1965 issue of *Radiological Health Data* (*3*).

Figure 4. Pan American Milk Network sampling locations

Table 5 presents stable calcium and potassium, strontium–90, strontium–89, and cesium–137 monthly average concentrations. The monthly average iodine–131 and barium–140 concentrations in milk were less than 10 pCi/liter.

Table 5. Stable elements and radionuclide concentrations in PAHO milk, December 1965

Sampling Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-89 (pCi/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Canal Zone:					
Cristobal	1.13	1.4	<5	5	30
Jamaica:					
Kingston	NS	NS	NS	NS	NS
Mandeville	NS	NS	NS	NS	NS
Montego Bay	1.22	1.32	<5	13	385
Puerto Rico:					
San Juan	1.11	1.5	<5	9	25
Venezuela:					
Caracas	NS	NS	NS	NS	NS

NS, no sample collected.

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STATE MILK SURVEILLANCE ACTIVITIES

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States have progressed to the level of comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes at this time. The results presented herein while not inclusive, are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

In addition to the networks presented herein, other State networks previously covered in *Radiological Health Data and Reports* include:

State milk network	Period reported	Last presented
California	July–September 1965	March 1966
Colorado	October–December 1964 and Summary 1962–1964	April 1965
Connecticut	April–September 1965	February 1966
Indiana	July–September 1965	February 1966
Michigan	July–September 1965	February 1966
Minnesota	January–June 1965	January 1966
New York	April–June 1965	January 1966
Oregon	July–September 1965	March 1966
Pennsylvania	July–September 1965	February 1966
Washington	July–September 1965	March 1966

1. Florida Milk Network July–December 1965

Division of Radiological and Occupational Health
Florida State Board of Health

The Florida State Board of Health began sampling raw milk for iodine–131 analysis in two major areas of the State in November 1962. The program has since been expanded to include the analysis of milk for strontium–89, strontium–90, and cesium–137. Raw milk samples are received from the six areas shown in figure 1. Samples for iodine–131 analysis are taken from a tank truck, whose route passes by farms widely dispersed over the area represented. Where there is no route representative of a large portion of an area, samples collected

Figure 1. Florida milk sampling areas

from selected farms are combined. When iodine–131 was detectable in milk, samples were collected weekly. In the interest of maintaining an active standby capability, samples are now collected monthly for iodine analysis. A regional State Board of Health laboratory is located in each of the six areas referred to in this report. Each laboratory prepares a monthly composite milk sample for its region by combining samples from 10 percent of the dairy farms selected at random. These composite samples are then sent to the State Radiological Health Laboratory in Orlando for analysis. Milk produced in the counties comprising each area is generally processed, marketed, and consumed in that area. These areas are characterized by differences in dairying practices related to the gradual transition from small farms in the west Florida region, where locally grown feeds are used, to larger farms in the southern areas, where different types of grass and predominantly purchased feeds are used.

Strontium–89 and strontium–90 are determined by the ion exchange method developed by Porter *et al.* (*1*). Iodine–131 and cesium–137 are determined by gamma-scintillation spectrometry (*2*).

Radionuclide concentration levels for July through December 1965 are presented in tables 1 and 2. During this period, strontium–89 determinations were not performed, because of extremely low levels; and iodine–131 concentrations were below detectable levels.

Table 1. Strontium-90 in Florida raw milk July–December 1965

Quarter	Analysis	Concentration (pCi/liter)					
		West Florida	North Florida	Northeast Florida	Central Florida	Tampa Bay area	Southeast Florida
Third [a]	1	34.1	20.6	12.7	7.2	11.6	11.0
	2	37.3	23.5	13.5	6.8	11.6	10.5
	Average	35.7	22.1	13.1	7.0	11.6	10.8
Fourth [b]	—	22.6	27.4	12.7	10.1	11.0	10.7

[a] Duplicate analyses performed.
[b] Duplicate analysis was not possible due to insufficient sample volume

Table 2. Cesium-137 in Florida raw milk July–December 1965

Month	Concentration (pCi/liter)						
	West Florida	North Florida	Northeast Florida	Central Florida	Tampa Bay area	Southeast Florida	Average
July	82	66	162	142	193	[a] 161	137
August	100	142	274	[b] 168	211	175	178
September	109	[b] 77	188	204	226	161	148
October	[b] 86	93	201	260	238	136	168
November	31	66	139	NA	151	120	109
December	NA	NA	NA	NA	128	73	—
Average	[a] 80	[a] 90	[a] 193	[a] 175	191	144	—

[a] Average calculated on the basis of incomplete data.
[b] Result represents average of two results from split samples, as part of quality control duplication.
NA, no analysis.

2. Oklahoma Milk Network August–December 1965

Oklahoma State Department of Health[1]

On March 15, 1965, the Radiological Health Section of the Oklahoma State Department of Health initiated a program of analysis for iodine–131 in milk produced in the State of Oklahoma.

The location of the sampling stations and the extent of their associated milksheds are shown in figure 2. Of the ten milksheds in the State of Oklahoma, five were chosen as sampling stations (Oklahoma City, Enid, Tulsa, Lawton, and Ardmore) on the basis of size and location. A major criterion in the selection of a milkshed for sampling was the degree of overlap with other milksheds being sampled. This overlap assists in locating small areas of production where the iodine–131 concentrations might be abnormally high.

The sampling stations are located in the laboratory of a major milk processing plant in each milkshed. While the milkshed for that particular processing plant may not coincide exactly with that shown in figure 2, the coincidence is satisfactory for surveillance purposes.

At the present time, samples are collected each Monday morning and the analyses are

[1] Acknowledgement is accorded to the staff of the Radiological Health Section under the direction of Mr. Dale McHard, head, and Mr. Robert Craig, assistant engineer.

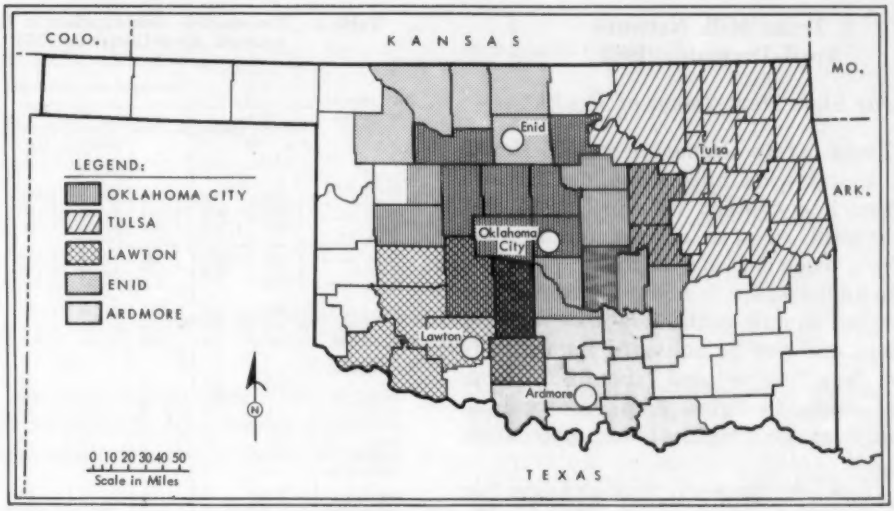

Figure 2. Oklahoma milkshed sampling areas

completed by Wednesday afternoon. However, if iodine–131 levels detected are such that diversion of the milk or other precautionary methods need to be taken, the analytical method and equipment can be employed to sample each truck arriving at the processing plant. Under these conditions, only about 4 hours would be needed to complete the analysis. This greatly reduced lag time for analysis would permit rapid decisions on the fate of each truckload of raw milk.

The ion exchange method of analysis used is similar to that recently published by the Public Health Service (*3*), but was developed independently by the Oklahoma State Health Department's Radiological Health Laboratory and has not been published to date. A description of the analytical procedures was presented in *Radiological Health Data* (*4*).

For the convenience of the reader, the sampling dates at the individual network stations are presented in table 3. During the 5-month period only one sample—that for Tulsa on October 25—showed iodine–131 activity above detectable limits.

Table 3. Concentration of iodine-131 in Oklahoma milk, August–December 1965

Date, 1965		Concentrations (pCi/liter)				
		Oklahoma City	Enid	Tulsa	Lawton	Ardmore
August	2	<1	<1	<1	<1	<1
	9	<1	<1	<1	<1	<1
	16	<1	NS	<1	<1	NS
	23	<1	<1	<1	<1	<1
	30	<1	<1	<1	<1	<1
September	6	<1	NS	<1	NS	<1
	13	<1	<1	<1	<1	<1
	20	<1	<1	<1	<1	<1
	27	<1	<1	<1	<1	<1
October	4	NS	NS	<1	<1	<1
	11	<1	<1	<1	<1	<1
	18	<1	NS	<1	<1	<1
	25	<1	NS	3.4	<1	<1
November	1	<1	<1	<1	<1	<1
	8	<1	NS	<1	<1	NS
	15	<1	<1	<1	<1	<1
	22	<1	<1	NS	NS	<1
	29	<1	<1	NS	NS	NS
December	6	<1	NS	<1	<1	<1
	13	NS	<1	<1	<1	<1
	20	<1	NS	<1	<1	<1
	27	<1	<1	<1	NS	<1

<1, below detection limit of 0.9 pCi/liter.
NS, no sample collected.

Previous coverage in *Radiological Health Data* and *Reports:*

Period	Issue
March–July 1965	October 1965

3. Texas Milk Network April–December 1965

Texas State Department of Health[2]

The Texas State Department of Health initiated a statewide milk sampling network for radionuclide content in April 1964. At present, monthly samples of raw milk are collected from each of six "active" sampling points. In addition, six "standby" stations have been supplied sample containers and shipping instructions and can be activated immediately if needed. The "active" and "standby" station locations, shown in figure 3, were chosen to give maximum geographical and population coverage.

Table 4 presents the April through December 1965 radionuclide concentrations in Texas milk. During this time, strontium–89, iodine–131, and barium–140 concentrations were below detectable levels. Strontium–90 and cesium–137 concentrations are shown graphically in figure 4 to indicate general trends.

[2] Acknowledgement is accorded to the staff of the Radiation Control Program, Division of Occupational Health and Radiation Control, under the direction of Mr. Martin C. Wukasch, chief engineer.

Table 4. Radionuclide concentrations in Texas milk network, April–December 1965

Radionuclide by month, 1965	Concentration, pCi/liter						
	Austin	Dallas	El Paso	Harlingen	Houston	Lubbock	Average
Potassium-40							
April	1,200	NS	1,310	1,300	1,370	1,320	1,300
May	1,260	NS	1,280	1,280	1,360	1,250	1,290
June	1,350	1,350	1,250	1,300	1,340	1,330	1,320
July	1,320	1,370	1,080	1,330	1,370	1,280	1,290
August	1,310	1,310	1,110	1,290	1,390	1,350	1,290
September	1,560	NS	1,250	1,290	1,280	1,370	1,351
October	NS	1,330	1,260	1,280	1,325	1,320	1,300
November	1,330	1,240	1,400	1,330	1,290	1,340	1,320
December	1,340	NS	1,250	1,330	1,270	1,300	1,300
Strontium-90							
April	6	NS	3	4	12	8	7
May	7	NS	4	3	13	6	6
June	7	10	5	4	12	7	9
July	5	19	5	5	8	6	8
August	NA	5	3	5	9	5	5
September	5	NS	9	5	7	9	7
October	NS	7	4	4	11	5	6
November	3	5	7	3	10	7	6
December	4	NS	3	4	9	10	6
Cesium-137							
April	20	NS	20	15	65	25	29
May	30	NS	10	20	60	15	27
June	30	40	20	20	45	30	31
July	80	30	20	15	40	20	34
August	10	15	10	20	40	20	19
September	15	NS	15	10	25	15	16
October	NS	15	10	5	25	15	14
November	30	15	30	5	25	10	19
December	20	NS	10	10	25	15	16

NS, no sample collected.
NA, no analysis.

Figure 3. Texas milk sampling stations

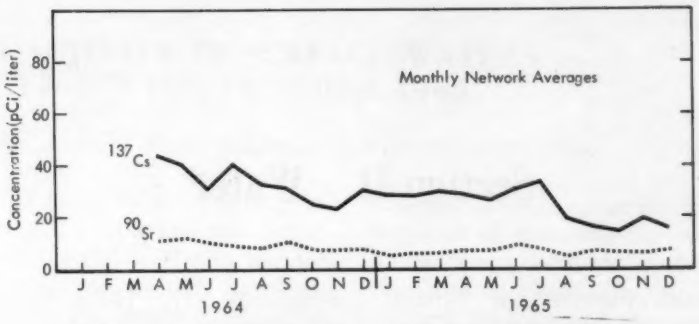

Figure 4. Radionuclide concentrations in Texas milk 1964—December 1965

Samples are routinely analyzed for strontium–89 and strontium–90 by a chemical separation technique employing ion exchange columns (*5*).

Potassium–40, iodine–131, cesium–137, and barium–140 concentrations are determined by gamma-scintillation spectrometry. Details of the analytical procedures were presented earlier (*6*).

Previous coverage in *Radiological Health Data:*

Period	Issue
1964 Summary	June 1965
January–March 1965	October 1965

REFERENCES

(*1*) PORTER, C., D. CAHILL, R. SCHNEIDER, P. ROBBINS, W. PERRY, and B. KAHN. Improved determination of strontium–90 in milk by an ion-exchange method. Anal Chem 33:1306 (September 1961).

(*2*) DIVISION OF RADIOLOGICAL AND OCCUPATIONAL HEALTH, FLORIDA STATE BOARD OF HEALTH. Florida milk network, July–December 1964. Radiological Health Data 6:611–612 (November 1965).

(*3*) PORTER, C. R., *et al.* Field method for rapid collection of iodine–131 from milk. Public Health Rep:453–456 (May 1965).

(*4*) OKLAHOMA STATE DEPARTMENT OF HEALTH. Oklahoma Milk Network, March–July 1965. Rad Health Data 6:540–541 (October 1965).

(*5*) PORTER, C., and B. KAHN. Improved determination of strontium–90 in milk by an ion exchange method. Anal Chem 36:676–678 (March 1964).

(*6*) TEXAS STATE DEPARTMENT OF HEALTH. Texas milk network, January–March 1965. Rad Health Data 6:541–542 (October 1965).

FOOD AND DIET SURVEILLANCE ACTIVITIES

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuous basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in routine operation and reported periodically include: (1) the Public Health Service's Institutional Total Diet Sampling Network, (2) the Atomic Energy Commission's Tri-City Diet Study, (3) the Food and Drug Administration's Teenage Diet Study, (4) the State of California's Diet Study, and (5) the State of Connecticut's Standard Diet Study. While not based on probability sampling, these networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Most recent coverage of programs reported in *Radiological Health Data and Reports* is listed below:

Program	Period reported	Last presented
Institutional Total Diet	April–June 1965	February 1966
Tri-City Diet	May–July 1965	March 1966
Teenage Diet	February–November 1964	July 1965
California Diet	January–April 1965	March 1966
Connecticut Standard Diet	March 1963–December 1964	July 1965

Section II. Water

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and/or treated (drinking) water. Most of these programs include determinations of gross alpha and gross beta radioactivity and/or specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the values secured with the Public Health Service Drinking Water Standards (*1*). These Standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for radium–226 and strontium–90 as 3 pCi/liter and 10 pCi/liter, respectively.

Limits may be higher if total intake of radioactivity from all sources indicates that such intakes are within the limits recommended by FRC for control action. In the known absence[1] of strontium–90 and alpha emitters, the limit is 1,000 pCi/liter gross beta activity. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends.

Water programs previously reported in *Radiological Health Data and Reports* are listed below:

Program	Period reported	Last presented
Radiostrontium in Tap Water, HASL	January–June 1965	December 1965
Colorado River Basin Sampling Network	1962–1964	November 1965
Coast Guard Water Sampling Program	1964	November 1965
Drinking Water Analysis Program	1962	October 1965
California Water Sampling Program	January–June 1965	March 1966
Florida Water Sampling Program	1964	November 1965
Kentucky Water Sampling Program	May 1963–June 1964	March 1965
Minnesota Surface Water Sampling Program	January–June 1965	February 1966
New York Surface Water Sampling Program	January–June 1965	January 1966
North Carolina Water Sampling Program	1964	November 1965
Lower Columbia River Radiological Survey in Oregon	August 1963–July 1964	October 1965
Washington Surface Water Sampling Program	July 1963–June 1964	February 1965

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, Revised 1962. PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation protection guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha emitters and strontium–90, respectively.

GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, OCTOBER 1965

Basic Data Program, Federal Water Pollution Control Administration

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as a part of the Public Health Service Water Pollution Surveillance System. Responsibility for this activity was transferred to the Federal Water Pollution Control Administration on December 31, 1965. Table 1 presents the current preliminary results of the alpha and beta analysis. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium–90 results are reported quarterly. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta activity in suspended-plus-dissolved solids in raw water collected at each geographical station. A description of the sampling and analytic procedures was published in the December 1965 *Radiological Health Data.*

Complete data and exact sampling locations are published in annual compilations (*1–6*) or are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data and for comment on the data, if needed. These arbitrary levels reflect no public health significance, as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes toward or from these arbitrary levels are also noted in terms of changes in radio-

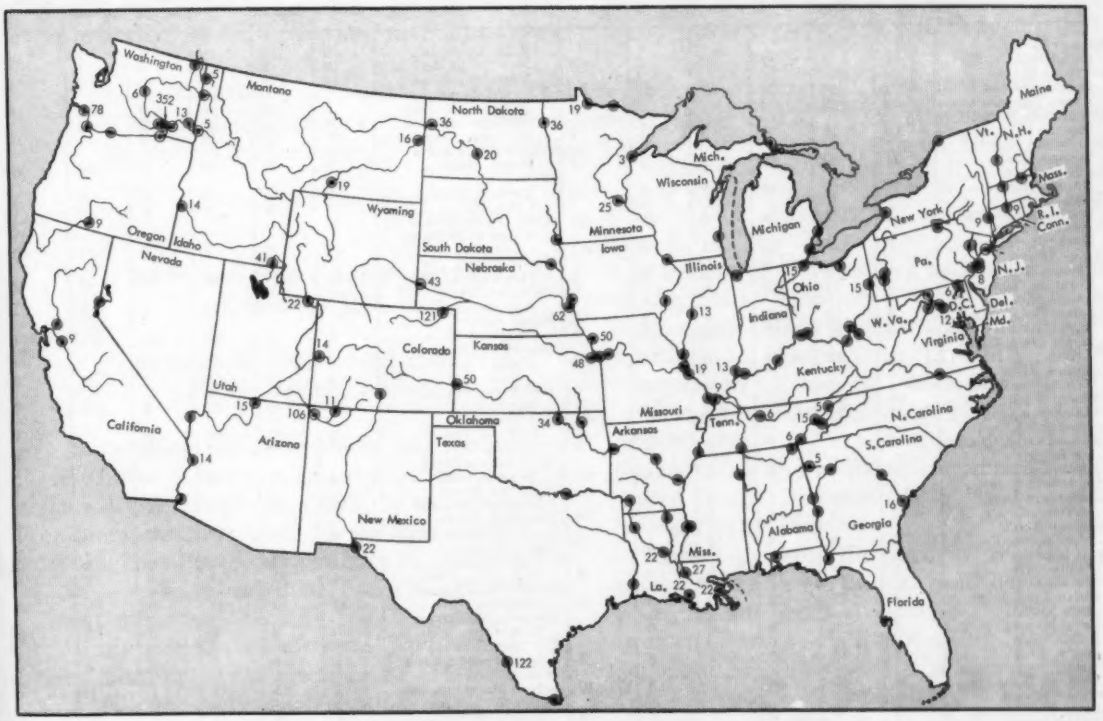

Figure 1. Sampling locations and associated total beta activity (pCi/liter) in surface waters, October 1965

activity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or suspended solids for all stations of the Water Pollution Surveillance System will be attempted at this time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During September and October 1965, the following stations showed alpha activity in excess of 15 pCi/liter or beta activity in excess of 150 pCi/liter in either the dissolved or the suspended solids: South Platte River, Julesburg, Colorado; North Platte River, Henry, Nebraska; Arkansas River, Coolidge, Kansas; Rio Grande, Laredo, Texas; Columbia River, Pasco, Washington; and San Juan River, Shiprock, New Mexico.

The Platte River of Plattsmouth decreased in both alpha and beta activities on suspended solids but increased in alpha activity on dissolved solids from September to October.

The following stations showed a decline in alpha activity on suspended solids to values of less than 15 pCi/liter: Atchafalaya River, Morgan City, Louisiana; Arkansas River, Ponca City, Oklahoma; and Kansas River, DeSoto, Kansas.

REFERENCES

(1) DIVISION OF WATER SUPPLY AND POLLUTION CONTROL, PUBLIC HEALTH SERVICE. National water quality network annual compilation of data. PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(2) *Ibid.*, 1959 Edition.
(3) *Ibid.*, 1960 Edition.
(4) *Ibid.*, 1961 Edition.
(5) *Ibid.*, 1962 Edition.
(6) DIVISION OF WATER SUPPLY AND POLLUTION CONTROL, PUBLIC HEALTH SERVICE. Water pollution surveillance system, annual compilation of data. PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Table 1. Radioactivity in raw surface waters, October 1965 (average concentrations in pCi/liter)

Station	Average beta activity (pCi/liter)			Average alpha activity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	4	7	11	1	2	3
Arkansas River:						
Coolidge, Kans.	11	39	50	3	23	26
Ponca City, Okla.	11	23	34	2	4	6
Atchafalaya River:						
Morgan City, La.	8	14	22	3	1	4
Bear River:						
Preston, Idaho	21	20	41	3	2	5
Big Horn River:						
Hardin, Mont.	6	13	19	1	6	7
Chena River:						
Fairbanks, Alaska	1	3	4	0	<1	<1
Clearwater River:						
Lewiston, Idaho	2	3	5	<1	0	<1
Clinch River:						
Clinton, Tenn.	1	4	5	0	0	0
Kingston, Tenn.	2	13	15	0	0	0
Colorado River:						
Loma, Colo.	2	12	14	1	6	7
Page, Ariz.	<1	15	15	0	3	3
Parker Dam, Calif.-Ariz.	2	12	14	0	5	5
Columbia River:						
Wenatchee, Wash.	1	5	6	0	0	0
Pasco, Wash.	61	291	352	0	<1	<1
Clatskanie, Ore.	7	71	78	0	<1	<1
Connecticut River:						
Enfield Dam, Conn.	2	7	9	0	0	0
Coosa River:						
Rome, Ga.	1	4	5	<1	0	<1
Cumberland River:						
Cheatham Lock, Tenn.	1	5	6	0	0	0
Delaware River:						
Philadelphia, Pa.	2	6	8	0	0	0
Great Lakes:						
Duluth, Minn.	0	3	3	0	0	0
Green River:						
Dutch John, Utah	<1	22	22	0	3	3
Hudson River:						
Poughkeepsie, N.Y.	1	8	9	0	0	0
Illinois River:						
Peoria, Ill.	3	10	13	1	3	4
Kansas River:						
De Soto, Kans.	28	20	48	7	3	10
Klamath River:						
Keno, Ore.	1	8	9	0	0	0
Maumee River:						
Toledo, Ohio	3	12	15	1	1	2
Mississippi River:						
St. Paul, Minn.	2	23	25	0	1	1
E. St. Louis, Ill.	6	13	19	1	2	3
New Roads, La.	19	8	27	6	1	7
New Orleans, La.	12	10	22	3	1	4
Missouri River:						
Williston, N. Dak.	3	33	36	0	6	6
Bismarck, N. Dak.	4	16	20	<1	3	3
St. Joseph, Mo.	27	23	50	8	4	12
North Platte River:						
Henry, Nebr.	3	40	43	0	30	30
Ohio River:						
Toronto, Ohio	2	13	15	0	0	0
Cairo, Ill.	1	8	9	0	0	0
Pend Oreille River:						
Albeni Falls Dam, Idaho	<1	5	5	0	<1	<1
Platte River:						
Plattsmouth, Nebr.	11	51	62	3	15	18
Potomac River:						
Washington, D.C.	1	11	12	0	1	1
Rainy River:						
Baudette, Minn.	3	16	19	<1	<1	<1
Red River, North:						
Grand Forks, N. Dak.	2	34	36	0	3	3
Red River, South:						
Alexandria, La.	10	12	22	2	1	3
Rio Grande:						
El Paso, Tex.	1	21	22	0	2	2
Laredo, Tex.	102	20	122	25	5	30
San Joaquin River:						
Vernalis, Calif.	4	5	9	1	1	2
San Juan River:						
Shiprock, N. Mex.	95	11	106	26	3	29
Savannah River:						
Port Wentworth, Ga.	3	13	16	<1	0	<1
Snake River:						
Payette, Idaho	2	12	14	0	6	6
Wawawai, Wash.	1	12	13	0	2	2
South Platte River:						
Julesburg, Colo.	32	89	121	10	66	76
Susquehanna River:						
Conowingo, Md.	0	6	6	0	0	0
Tennessee River:						
Chattanooga, Tenn.	1	5	6	0	0	0
Wabash River:						
New Harmony, Ind.	2	11	13	1	1	2
Yellowstone River:						
Sidney, Mont.	6	10	16	1	3	4
Maximum	102	291	352	26	66	76
Minimum	0	3	3	0	0	0

Section III. Air and Deposition

RADIOACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity. To date, this surveillance has been confined chiefly to gross beta analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used for determining when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson (*1*) in 1962. In addition to the programs presented in this issue, the results of other air and deposition programs have been previously covered in *Radiological Health Data and Reports*:

Program	Period reported	Last presented
HASL Fallout Network	April–December 1964	September 1965
Mexican Air Monitoring	November 1965	March 1966

1. Radiation Surveillance Network December 1965

Division of Radiological Health
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) which regularly gathers samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta activity made by the station operators prior to submission of the samples. When high air levels are reported, appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (*2*). A detailed description of the sampling and analysis procedures was presented in the December 1965 issue of *Radiological Health Data*.

Table 1 presents the monthly average gross beta activity in surface air and deposition by precipitation during December 1965. Time profiles of gross beta in air dating back to 1958 for eight RSN stations are shown in figure 2. Gamma spectroscopy analysis was performed on 302 air samples. No traces of fresh fission products were identified in these samples.

Figure 1. Radiation Surveillance Network sampling stations

2. Canadian Air and Precipitation Monitoring Program December 1965 [1]

Radiation Protection Division
Department of National Health and Welfare
Ottawa, Canada

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (see figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3–7*).

A summary of the sampling procedures and methods of analysis was presented in the December 1965 issue of *Radiological Health Data.*

Surface air and precipitation data for December 1965 are presented in table 2. Specific radionuclide data are presented in table 3.

[1] Prepared from information and data in the January 1966 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 1. Gross beta activity in surface air and precipitation, December 1965

Station location		Air surveillance						Precipitation	
		Number of samples		Gross beta activity, pCi/m³			Last profile in *RHD & R*	Total depth (mm)	Total deposition (nCi/m²)[a]
		Air	Pptn	Maximum	Minimum	Average[a]			
Ala:	Montgomery	30	5	0.13	<0.10	<0.10	Feb 66	118	<24
Alaska:	Adak	29		0.12	<0.10	<0.10	Sep 65	[b]	
	Anchorage	22		<0.10	<0.10	<0.10	Mar 66	[b]	
	Attu Island	4		<0.10	<0.10	<0.10	Oct 65	[b]	
	Fairbanks	18	5	<0.10	<0.10	<0.10	Apr 66	18	<4
	Juneau	22	17	<0.10	<0.10	<0.10	Jul 65	200	<40
	Kodiak	6		0.12	<0.10	<0.11	Aug 65	[b]	
	Nome	14		<0.10	<0.10	<0.10	Dec 65	[b]	
	Pt. Barrow	27		<0.10	<0.10	<0.10	Nov 65	[b]	
	St. Paul Island	13		<0.10	<0.10	<0.10	Jan 66	[b]	
Ariz:	Phoenix	30		0.19	<0.10	<0.11	Jul 65	[b]	
Ark:	Little Rock	25	4	0.12	<0.10	<0.10	Mar 66	41	<8
Calif:	Berkeley	23	5	0.18	<0.10	<0.11	Aug 65	85	<17
	Los Angeles	22	8	0.18	<0.10	<0.11	Dec 65	144	<29
C.Z:	Ancon	17		<0.10	<0.10	<0.10	Aug 65	[b]	
Colo:	Denver	28	2	0.18	<0.10	<0.11	Aug 65	4	<1
Conn:	Hartford	31	6	<0.10	<0.10	<0.10	Apr 66	42	<8
Del:	Dover	20		<0.10	<0.10	<0.10	Feb 66	[b]	
D.C:	Washington	31	2	<0.10	<0.10	<0.10	Nov 65	11	<2
Fla:	Jacksonville	28	6	0.11	<0.10	<0.10	Mar 66	108	<22
	Miami	30	2	0.15	<0.10	<0.10	Apr 66	15	<3
Ga:	Atlanta	[c]	3				Jan 66	23	<5
Guam:	Agana	31		<0.10	<0.10	<0.10	Feb 66	[b]	
Hawaii:	Honolulu	30	7	<0.10	<0.10	<0.10	Oct 65	133	<27
Idaho:	Boise	30	1	0.25	<0.10	<0.11	Oct 65	2	0
Ill:	Springfield	30		0.14	<0.10	<0.11	Nov 65	[b]	
Ind:	Indianapolis	27	6	0.13	<0.10	<0.10	Jan 66	46	<9
Iowa:	Iowa City	28	4	<0.10	<0.10	<0.10	Aug 65	66	<13
Kans:	Topeka	31	4	<0.10	<0.10	<0.10	Mar 66	44	<9
Ky:	Frankfort	28	5	0.17	<0.10	<0.11	Nov 65	14	<3
La:	New Orleans	28	11	<0.10	<0.10	<0.10	Nov 65	189	<38
Maine:	Augusta	31	6	<0.10	<0.10	<0.10	Dec 65	54	<11
	Presque Isle	23		<0.10	<0.10	<0.10	Aug 65	[b]	
Md:	Baltimore	21	2	0.13	<0.10	<0.10	Apr 66	20	<4
	Rockville	14		<0.10	<0.10	<0.10	Oct 65	[b]	
Mass:	Lawrence	30	4	0.12	<0.10	<0.10	Feb 66	29	<6
	Winchester	31	3	<0.10	<0.10	<0.10	Sep 65	29	<6
Mich:	Lansing	31		0.11	<0.10	<0.10	Oct 65	[b]	
Minn:	Minneapolis	23	5	<0.10	<0.10	<0.10	Feb 66	30	<6
Miss:	Jackson	29	4	<0.10	<0.10	<0.10	Dec 65	68	<14
Mo:	Jefferson City	29	8	<0.10	<0.10	<0.10	Jan 66	58	<12
Mont:	Helena	31	3	0.14	<0.10	<0.10	Sep 65	4	<1
Nebr:	Lincoln	18		<0.10	<0.10	<0.10	Jan 66	[b]	
Nev:	Las Vegas	26		0.19	<0.10	<0.11	Apr 66	[b]	
N.H:	Concord	12		<0.10	<0.10	<0.10	Nov 65		
N.J:	Trenton	31	3	0.11	<0.10	<0.10	Dec 65	12	<2
N.Mex.	Santa Fe	27	9	<0.10	<0.10	<0.10	Sep 65	34	<7
N.Y:	Albany	21	4	<0.10	<0.10	<0.10	Jan 66	17	<3
	Buffalo	31		<0.10	<0.10	<0.10	Aug 65	[b]	
	New York	28		<0.10	<0.10	<0.10	Sep 65	[b]	
N.C:	Gastonia	30	2	0.13	<0.10	<0.10	Aug 65	10	<2
N.Dak:	Bismarck	29	2	<0.10	<0.10	<0.10	Nov 65	6	<1
Ohio:	Cincinnati	13		<0.10	<0.10	<0.10	Feb 66	[b]	
	Columbus	28	3	0.15	<0.10	<0.11	Dec 65	15	<3
	Painesville	30	6	0.13	<0.10	<0.10	Apr 66	36	<7
Okla:	Oklahoma City	28	4	0.11	<0.10	<0.10	Oct 65	63	<13
	Ponca City	24	6	<0.10	<0.10	<0.10	Apr 66	67	<14
Ore:	Portland	28	15	0.18	<0.10	<0.11	Jan 66	88	<18
Pa:	Harrisburg	29	2	<0.10	<0.10	<0.10	Jan 66	21	<4
P.R:	San Juan	27	5	<0.10	<0.10	<0.10	Dec 65	157	<31
R.I:	Providence	29	2	<0.10	<0.10	<0.10	Oct 65	30	<6
S.C:	Columbia	30	5	0.14	<0.10	<0.10	Sep 65	15	<3
S.Dak:	Pierre	31	1	<0.10	<0.10	<0.10	Jul 65	6	<1
Tenn:	Nashville	31	4	<0.10	<0.10	<0.10	Oct 65	24	<5
Tex:	Austin	28	11	0.11	<0.10	<0.10	Feb 66	140	<28
	El Paso	31	10	0.14	<0.10	<0.10	Nov 65	22	<5
Utah:	Salt Lake City	31	9	0.13	<0.10	<0.10	Dec 65	42	<9
Vt:	Barre	28	8	0.15	<0.10	<0.10	Mar 66	37	<8
Va:	Richmond	30	3	<0.10	<0.10	<0.10	Mar 66	7	<2
Wash:	Seattle	29	18	<0.10	<0.10	<0.10	Mar 66	130	<28
	Spokane	28	2	0.12	<0.10	<0.10	Feb 66	8	<2
W. Va:	Charleston	27	4	<0.10	<0.10	<0.10	Sep 65	7	<2
Wis:	Madison	30	6	<0.10	<0.10	<0.10	Mar 66	63	<13
Wyo:	Cheyenne	31	2	0.12	<0.10	<0.10	Apr 66	5	<1
Network summary		1,900	284	0.25	<0.10	<0.10		50	<10

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the < values represent more than 10 percent of the average, a less-than sign is placed before the average.
[b] Indicates no precipitation sample collected. [c] Indicates no report received.

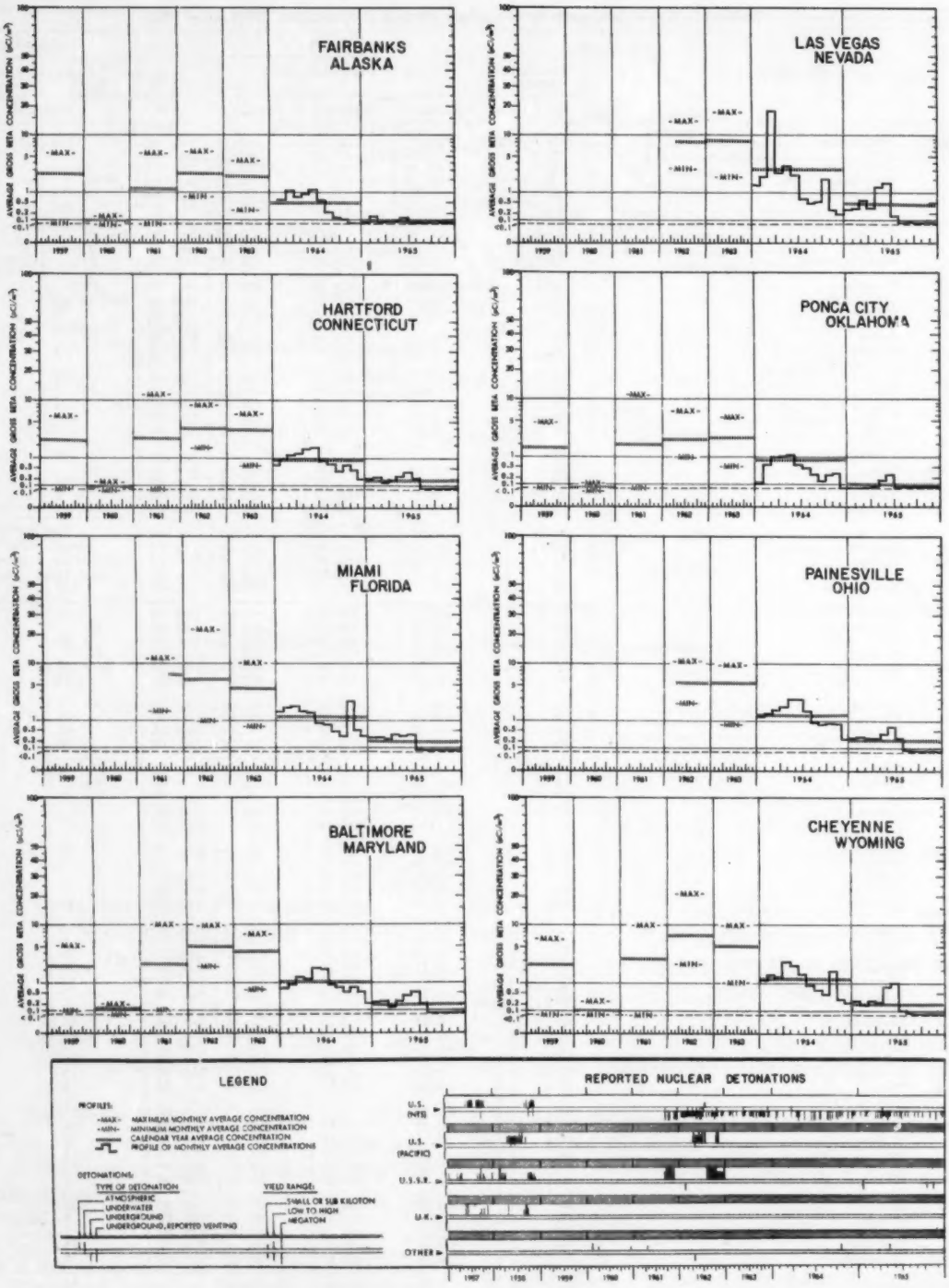

Figure 2. Monthly and yearly profiles of beta activity in air, Radiation Surveillance Network, 1959–December 1965

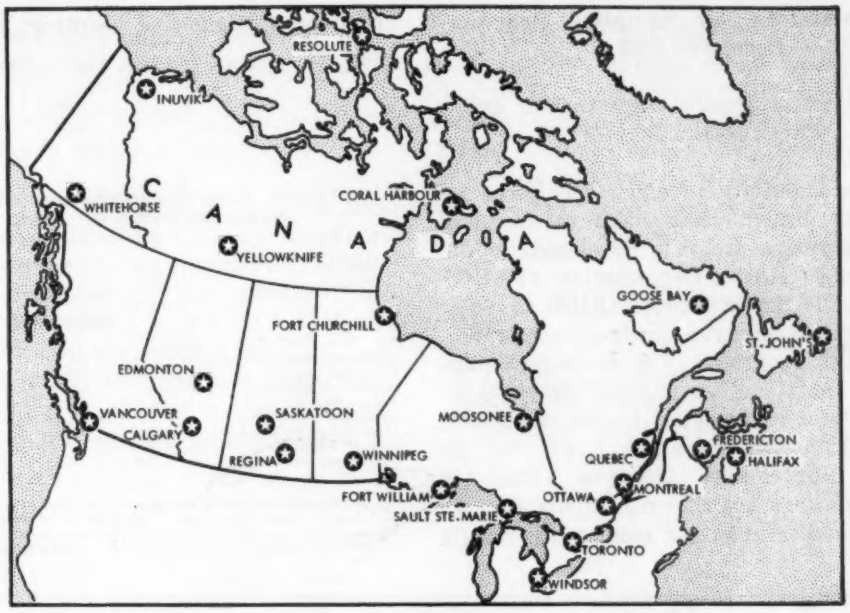

Figure 3. Canadian air and precipitation sampling stations

Table 2. Canadian gross beta activity in surface air and precipitation, December 1965

Station	Air surveillance				Precipitation measurements	
	Number of samples	Activity (pCi/m³)			Average concentration (pCi/liter)	Total deposition (nCi/m²)
		Maximum	Minimum	Average		
Calgary	31	0.2	0.0	0.1	67	0.5
Coral Harbour	31	0.1	0.0	0.1	64	0.6
Edmonton	31	0.1	0.0	0.1	39	0.7
Ft. Churchill	31	0.1	0.0	0.1	44	0.5
Ft. William	31	0.1	0.0	0.1	25	1.3
Fredericton	31	0.1	0.0	0.1	13	0.9
Goose Bay	31	0.1	0.0	0.1	15	0.7
Halifax	31	0.1	0.0	0.1	32	2.2
Inuvik	31	0.1	0.0	0.1	12	0.3
Montreal	30	0.2	0.0	0.1	49	2.4
Moosonee	31	0.1	0.0	0.1	17	0.5
Ottawa	31	0.2	0.0	0.1	26	2.0
Quebec	29	0.1	0.0	0.1	35	2.7
Regina	31	0.1	0.0	0.1	31	0.7
Resolute	31	0.1	0.0	0.1	NA	NA
St. John's, Nfld.	25	0.1	0.0	0.0	14	1.3
Saskatoon	31	0.1	0.0	0.0	NS	NS
Sault Ste. Marie	31	0.1	0.0	0.1	15	1.2
Toronto	31	0.2	0.0	0.1	NS	NS
Vancouver	31	0.1	0.0	0.0	22	3.9
Whitehorse	31	0.1	0.0	0.0	25	0.5
Windsor	31	0.2	0.0	0.1	27	3.2
Winnipeg	30	0.1	0.0	0.1	37	1.4
Yellowknife	31	0.1	0.0	0.1	46	0.4
Network summary	—	0.1	0.0	0.1	31	1.3

NA, no analysis performed
NS, no sample collected

Table 3. Radionuclide deposition in Canadian fallout December 1965 [a]

Station	Strontium-90 (nCi/m²)	Cesium-137 (nCi/m²)
Calgary	0.02	0.07
Coral Harbour	0.05	0.08
Edmonton	0.03	0.09
Ft. Churchill	0.04	0.06
Ft. William	0.14	0.14
Fredericton	0.05	0.13
Goose Bay	0.10	0.10
Halifax	0.11	0.13
Inuvik	0.00	0.03
Montreal	0.21	0.25
Moosonee	0.03	0.05
Ottawa	0.15	0.20
Quebec	0.23	0.56
Regina	0.00	0.04
Resolute	0.05	0.15
St. John's, Nfld	0.13	0.22
Saskatoon	NS	NS
Sault Ste. Marie	0.13	0.14
Toronto	NS	NS
Vancouver	0.43	0.67
Whitehorse	0.01	0.01
Windsor	0.25	0.33
Winnipeg	0.04	0.06
Yellowknife	0.02	0.02
Average	0.10	0.16

[a] Strontium-89, zirconium-95, and barium-140 are not reported, due to insignificantly low levels.
NS, no sample collected

3. Pan American Air Sampling Program December 1965

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by countries in the Americas under the auspices of a collaborative program developed by the Pan American Health Organization (PAHO) and the Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with these employed for the Radiation Surveillance Network. The air sampling stations are shown in figure 4.

The December 1965 air monitoring results from the participating countries are given in table 4.

Table 4. Gross beta activity in surface air and precipitation, PAHO, December 1965

Station location	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average [a]
Argentina: Buenos Aires	19	<0.10	<0.10	<0.10
Chili: Santiago	25	<0.10	<0.10	<0.10
Jamaica: Kingston	25	<0.10	<0.10	<0.10
Peru: Lima	6	<0.10	<0.10	<0.10
Venezuela: Caracas	20	0.12	<0.10	<0.10
West Indies: Trinidad	6	<0.10	<0.10	<0.10
Pan American summary	101	0.12	<0.10	<0.10

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the < values represent more than 10 percent of the average, a less-than sign is placed before the average.

Figure 4. Pan American Air Network sampling stations

4. National Air Sampling Network October–December and Annual Summary, 1965

Division of Air Pollution
Public Health Service

The necessity of having basic data on the nature and extent of air pollution throughout the United States led to the organization of the National Air Sampling Network (NASN) in 1953. One of the many analyses performed on air samples collected through the NASN is for gross beta radioactivity. NASN stations (figure 5) are manned by cooperating Federal, State, and local agencies. The network consists of 110 sampling stations which operate every year and 130 stations which operate every other year. A description of the sampling network was presented in the December 1965 issue of *Radiological Health Data*. Fourth quarter 1965 gross beta activities in air are given in table 5. Data for 1965 are summarized in table 6.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
Annual Summary 1964	April 1965
January–March 1965	July 1965
April–June 1965	October 1965
July–September 1965	January 1966

Figure 5. National Air Sampling Network station locations

Table 5. Fission product gross beta activity in surface air NASN, fourth quarter 1965

(Concentrations in pCi/m³)

	Station name	Number of samples	Maximum	Minimum	Average
Ala:	Birmingham	5	0.2	0.1	0.1
	Huntsville	6	0.2	0.1	0.1
	Montgomery	6	0.2	0.1	0.1
Ariz:	Grand Canyon Park*	5	0.2	0.1	0.2
	Paradise Valley	6	0.2	0.1	0.2
	Phoenix	6	0.2	0.1	0.2
	Tucson	7	0.2	0.1	0.1
Ark:	Little Rock	6	0.2	0.1	0.2
	Montgomery County*	6	0.2	0.1	0.1
Calif:	Glendale	6	0.2	0.1	0.1
	Humboldt County*	5	0.1	<0.1	0.1
	Long Beach	6	0.1	0.1	0.1
	Los Angeles	6	0.2	0.1	0.1
	Oakland	6	0.3	<0.1	0.1
	San Diego	6	0.1	0.1	0.1
	San Francisco	6	0.2	0.1	0.1
Colo:	Denver	6	0.2	0.1	0.1
	Montezuma County*	5	0.1	<0.1	0.1
Conn:	Hartford	6	0.1	<0.1	0.1
	New Britain	6	0.1	0.1	0.1
	New Haven	6	0.2	0.1	0.1
	Norwich	6	0.1	0.1	0.1
	Waterbury	6	0.1	0.1	0.1
Del:	Kent County*	5	0.1	0.1	0.1
	Newark	6	0.2	0.1	0.1
	Wilmington	5	0.1	0.1	0.1
D.C:	Washington	5	0.1	0.1	0.1
Ga:	Atlanta	6	0.2	0.1	0.1
Hawaii:	Honolulu	6	0.1	<0.1	0.1
Idaho:	Boise	6	0.2	0.1	0.2
	Butte County*	5	0.2	0.1	0.1
Ill:	Chicago	6	0.2	<0.1	0.1
	East St. Louis	6	0.2	0.1	0.1
	Joliet	6	0.1	0.1	0.1
	North Chicago	4	0.2	0.1	0.2
	Rockford	6	0.2	<0.1	0.1
	Springfield	6	0.1	0.1	0.1
Ind:	East Chicago	6	0.2	<0.1	0.1
	Hammond	6	0.2	<0.1	0.1
	Indianapolis	6	0.2	0.1	0.1
	Parke County*	6	0.2	<0.1	0.1
	Portage	7	0.2	<0.1	0.1
	Beverly Shores	5	0.2	0.1	0.1
	Dunes Police Post #1	5	0.2	0.1	0.1
	Dunes State Park	6	0.1	<0.1	0.1
	Ogden Dunes	6	0.2	<0.1	0.1
	South Bend	5	0.1	<0.1	0.1
Iowa:	Cedar Rapids	6	0.2	0.1	0.1
	Delaware County*	6	0.2	<0.1	0.1
	Des Moines	6	0.2	0.1	0.1
Kans:	Topeka	6	0.2	0.1	0.1
	Wichita	6	0.2	0.1	0.1
Ky:	Lexington	5	0.2	0.1	0.2
	Louisville	6	0.1	0.1	0.1
La:	New Orleans	6	0.2	0.1	0.1
	Shreveport	6	0.2	<0.1	0.1
Maine:	Acadia Nat Park*	5	0.1	0.1	0.1
	Portland	6	0.1	<0.1	0.1
Md:	Baltimore	6	0.2	0.1	0.1
	Calvert County*	6	0.2	0.1	0.1
Mass:	Brockton	6	0.1	0.1	0.1
	Lawrence	4	0.1	0.1	0.1
	Lowell	7	0.2	0.1	0.1
	New Bedford	5	0.2	<0.1	0.1
Mich:	Detroit	6	0.2	<0.1	0.1
	Flint	6	0.1	0.1	0.1
	Grand Rapids	5	0.1	<0.1	0.1
	Trenton	6	0.2	0.1	0.1
Minn:	Minneapolis	6	0.2	<0.1	0.1
	St Paul	6	0.2	<0.1	0.1
Miss:	Jackson	5	0.2	0.1	0.1
	Jackson County*	6	0.1	0.1	0.1
Mo:	Kansas City	6	0.2	0.1	0.2
	St. Louis	6	0.2	0.1	0.1
	Shannon County*	7	0.2	0.1	0.1
Mont:	Glacier Nat Park*	6	0.1	0.1	0.1
	Helena	5	0.2	0.1	0.1
Nebr:	Omaha	6	0.2	0.1	0.1
	Thomas County*	6	0.2	0.1	0.2
Nev:	Las Vegas	6	0.3	0.1	0.2
	Reno	5	0.2	0.1	0.2
	White Pine County*	6	0.1	0.1	0.1
N.H:	Concord	5	0.1	0.1	0.1
	Coos County*	6	0.2	<0.1	0.1
N.J:	Bayonne	3	0.2	0.1	0.1
	Bridgeton	6	0.2	0.1	0.1
	Pemberton	6	0.2	<0.1	0.1
	Marlton	6	0.2	0.1	0.1
N.J.—Continued					
	Glassboro	6	0.1	0.1	0.1
	Hamilton	6	0.2	0.1	0.1
	Jutland	7	0.1	<0.1	0.1
	Jersey City	6	0.2	<0.1	0.1
	Newark	5	0.1	0.1	0.1
	New Brunswick	4	0.1	0.1	0.1
	Paterson	5	0.2	0.1	0.1
	Perth Amboy	5	0.2	0.1	0.1
	Princeton	4	0.2	0.1	0.1
N.Mex:	Albuquerque	6	0.2	<0.1	0.1
	Rio Arriba County*	6	0.1	0.1	0.1
N.Y:	Cape Vincent*	6	0.1	0.1	0.1
	New York City	6	0.1	<0.1	0.1
N.C:	Charlotte	6	0.2	0.1	0.1
	Cape Hatteras*	6	0.2	0.1	0.1
Ohio:	Akron	6	0.2	0.1	0.1
	Cincinnati	6	0.2	0.1	0.2
	Cleveland	6	0.2	<0.1	0.1
	Columbus	6	0.2	0.1	0.1
	Toledo	6	0.2	0.1	0.1
	Youngstown	6	0.2	0.1	0.1
Okla:	Cherokee County*	6	0.2	0.1	0.2
	Oklahoma City	6	0.2	0.1	0.2
	Tulsa	6	0.2	<0.1	0.1
Ore:	Curry County*	6	0.1	<0.1	<0.1
	Eugene	6	0.2	<0.1	0.1
	Medford	5	0.1	<0.1	0.1
	Portland	5	0.2	<0.1	0.1
Pa:	Allentown	6	0.1	0.1	0.1
	Altoona	5	0.1	0.1	0.1
	Bethlehem	6	0.2	0.1	0.1
	Pipersville	6	0.1	0.1	0.1
	Embreeville	6	0.1	0.1	0.1
	Clarion County*	6	0.1	<0.1	0.1
	Erie	5	0.1	<0.1	0.1
	Johnstown	6	0.2	0.1	0.1
	Lancaster	6	0.2	0.1	0.1
	Eagleville	4	0.1	0.1	0.1
	Sanatoga	5	0.2	<0.1	0.1
	Philadelphia	6	0.2	0.1	0.1
	Pittsburgh	6	0.2	0.1	0.1
	Reading	6	0.2	0.1	0.1
	Warminster	6	0.1	<0.1	0.1
	West Chester	5	0.1	<0.1	0.1
	York	6	0.1	0.1	0.1
P.R:	Bayamón	6	0.1	<0.1	0.1
	Guayanilla	5	0.1	<0.1	<0.1
	Ponce	6	0.1	<0.1	0.1
	San Juan	5	0.1	<0.1	0.1
R.I:	East Providence	6	0.1	<0.1	0.1
	Providence	6	0.2	0.1	0.1
	Washington County*	6	0.2	0.1	0.1
S.C:	Charleston	7	0.2	0.1	0.1
	Columbia	5	0.2	0.1	0.1
	Richland County*	6	0.2	0.1	0.1
	Spartanburg	6	0.2	0.1	0.2
S.Dak:	Black Hills Forest*	6	0.2	0.1	0.1
	Sioux Falls	6	0.2	0.1	0.1
Tenn:	Chattanooga	6	0.2	0.1	0.2
	Knoxville	6	0.1	<0.1	0.1
	Memphis	7	0.3	0.1	0.1
	Nashville	5	0.2	<0.1	0.1
Tex:	Dallas	6	0.3	<0.1	0.2
	Houston	6	0.2	<0.1	0.1
	Matagorda County*	6	0.1	<0.1	0.1
	San Antonio	5	0.2	0.1	0.1
Utah:	Salt Lake City	6	0.2	0.1	0.2
Vt:	Burlington	6	0.1	<0.1	0.1
	Orange County*	6	0.1	0.1	0.1
Va:	Hampton	6	0.2	0.1	0.1
	Lynchburg	5	0.2	0.1	0.1
	Norfolk	6	0.1	0.1	0.1
	Shenandoah Nat Park*	5	0.1	0.1	0.1
	Portsmouth	6	0.1	<0.1	0.1
	Richmond	6	0.2	0.1	0.1
	Roanoke	5	0.1	0.1	0.1
Wash:	Seattle	5	0.1	<0.1	0.1
W. Va:	Charleston	6	0.2	0.1	0.1
	Weirton	5	0.1	0.1	0.1
	Wheeling	5	0.2	0.1	0.1
Wis:	Door County*	6	0.2	<0.1	0.1
	Kenosha	6	0.2	0.1	0.1
	Madison	6	0.2	<0.1	0.1
	Milwaukee	6	0.2	<0.1	0.1
Wyo:	Cheyenne	6	0.2	<0.1	0.1
	Yellowstone Park*	5	0.1	0.1	0.1

* Denotes nonurban station.

Table 6. Fission product gross beta activity in surface air, NASN, annual summary 1965

(Concentrations in pCi/m³)

Station name		Number of samples	Maximum	Minimum	Average
Ala:	Birmingham	24	1.1	0.1	0.3
	Huntsville	26	1.1	<0.1	0.4
	Montgomery	25	1.1	0.1	0.3
Ariz:	Grand Canyon Park*	24	1.3	0.1	0.4
	Paradise Valley	26	2.0	0.1	0.6
	Phoenix	26	1.7	<0.1	0.5
	Tucson	25	8.8	0.1	0.7
Ark:	Little Rock	23	1.4	0.1	0.3
	Montgomery County*	21	0.7	0.1	0.3
Calif:	Glendale	26	1.2	0.1	0.4
	Humboldt County*	24	0.6	<0.1	0.2
	Long Beach	25	1.4	0.1	0.4
	Los Angeles	23	1.2	0.1	0.4
	Oakland	24	0.7	<0.1	0.2
	San Diego	25	0.8	0.1	0.3
	San Francisco	26	0.7	0.1	0.2
Colo:	Denver	24	1.6	0.1	0.4
	Montezuma County*	23	1.4	<0.1	0.5
Conn:	Hartford	26	1.2	<0.1	0.4
	New Britain	26	1.2	0.1	0.4
	New Haven	24	1.2	<0.1	0.3
	Norwich	24	1.2	0.1	0.4
	Waterbury	26	1.3	0.1	0.4
Del:	Kent County*	23	1.0	0.1	0.3
	Newark	24	1.3	<0.1	0.3
	Wilmington	23	1.1	0.1	0.3
D.C:	Washington	24	1.3	0.1	0.3
Ga:	Atlanta	24	0.9	<0.1	0.3
Hawaii:	Honolulu	26	3.0	<0.1	0.4
Idaho:	Boise	25	1.2	0.1	0.4
	Butte County*	23	1.4	<0.1	0.4
Ill:	Chicago	24	0.8	<0.1	0.3
	East St. Louis	25	1.5	0.1	0.4
	Joliet	23	0.6	0.1	0.3
	North Chicago	21	0.9	0.1	0.3
	Rockford	26	0.9	<0.1	0.3
	Springfield	25	0.7	0.1	0.3
Ind:	East Chicago	25	0.8	<0.1	0.3
	Hammond	25	0.9	<0.1	0.3
	Indianapolis	25	1.2	0.1	0.3
	Parke County*	25	1.1	<0.1	0.3
	Portage	23	1.1	<0.1	0.3
	Beverly Shores	25	0.8	0.1	0.3
	Dunes Police Post #1	23	1.0	0.1	0.3
	Dunes State Park	23	1.0	<0.1	0.2
	Ogden Dunes	24	0.6	<0.1	0.2
	South Bend	23	1.8	<0.1	0.4
Iowa:	Cedar Rapids	26	0.8	0.1	0.3
	Delaware County*	25	0.6	<0.1	0.2
	Des Moines	25	1.1	0.1	0.3
Kans:	Topeka	25	1.6	0.1	0.3
	Wichita	26	1.0	0.1	0.3
Ky:	Lexington	24	1.4	0.1	0.4
	Louisville	23	0.6	0.1	0.3
La:	New Orleans	25	1.3	<0.1	0.3
	Shreveport	26	1.3	<0.1	0.3
Maine:	Acadia Nat Park*	22	0.7	0.1	0.3
	Portland	23	1.3	<0.1	0.3
Md:	Baltimore	26	2.4	<0.1	0.4
	Calvert County*	26	0.8	0.1	0.3
Mass:	Brockton	24	1.2	0.1	0.3
	Lawrence	23	2.0	0.1	0.4
	Lowell	23	2.0	0.1	0.4
	New Bedford	20	1.5	<0.1	0.5
Mich:	Detroit	24	1.5	<0.1	0.4
	Flint	25	1.3	<0.1	0.3
	Grand Rapids	23	0.8	<0.1	0.3
	Trenton	25	1.3	0.1	0.4
Minn:	Minneapolis	26	0.8	<0.1	0.3
	St Paul	26	0.8	<0.1	0.3
Miss:	Jackson	24	1.6	0.1	0.4
	Jackson County*	25	1.4	<0.1	0.3
Mo:	Kansas City	24	0.7	0.1	0.3
	St Louis	25	1.2	0.1	0.3
	Shannon County*	26	0.9	0.1	0.3
Mont:	Glacier Nat Park*	23	1.0	0.1	0.3
	Helena	22	1.4	<0.1	0.4
Nebr:	Omaha	25	0.8	0.1	0.3
	Thomas County*	26	0.9	<0.1	0.3
Nev:	Las Vegas	26	1.9	0.1	0.6
	Reno	25	1.4	0.1	0.5
	White Pine County*	23	1.4	0.1	0.4
N.H:	Concord	25	1.0	0.1	0.4
	Coos County*	23	0.9	<0.1	0.3
N.J:	Bayonne	19	1.8	0.1	0.5
	Bridgeton	24	0.8	<0.1	0.3
	Pemberton	26	1.0	<0.1	0.3
N.J.—Continued					
	Marlton	23	1.3	<0.1	0.3
	Glassboro	24	1.1	<0.1	0.3
	Hamilton	24	1.4	<0.1	0.3
	Jutland	23	1.1	<0.1	0.3
	Jersey City	26	1.3	<0.1	0.3
	Newark	24	2.0	<0.1	0.4
	New Brunswick	22	0.9	0.1	0.3
	Paterson	24	1.8	<0.1	0.4
	Perth Amboy	24	1.6	<0.1	0.4
	Princeton	21	0.7	0.1	0.3
N.Mex:	Albuquerque	25	1.6	<0.1	0.4
	Rio Arriba County*	25	2.6	<0.1	0.5
N.Y:	Cape Vincent*	25	1.2	0.1	0.4
	New York City	24	1.2	<0.1	0.3
N.C:	Charlotte	26	1.2	0.1	0.3
	Cape Hatteras*	26	0.8	0.1	0.3
Ohio:	Akron	25	1.3	0.1	0.4
	Cincinnati	25	1.2	0.1	0.4
	Cleveland	26	3.6	<0.1	0.5
	Columbus	25	1.4	0.1	0.4
	Toledo	26	1.5	<0.1	0.4
	Youngstown	26	1.3	<0.1	0.4
Okla:	Cherokee County*	25	1.3	0.1	0.4
	Oklahoma City	26	0.9	0.1	0.3
	Tulsa	25	0.8	<0.1	0.3
Ore:	Curry County*	24	0.5	<0.1	0.2
	Eugene	26	0.5	<0.1	0.2
	Medford	24	0.9	<0.1	0.3
	Portland	25	0.8	<0.1	0.3
Pa:	Allentown	22	1.7	0.1	0.3
	Altoona	21	1.4	0.1	0.5
	Bethlehem	24	2.0	<0.1	0.4
	Pipersville	23	1.7	0.1	0.3
	Embreeville	24	1.0	0.1	0.3
	Clarion County*	25	1.8	<0.1	0.3
	Erie	24	1.6	<0.1	0.4
	Johnstown	24	0.8	0.1	0.3
	Lancaster	25	1.1	<0.1	0.4
	Eagleville	21	1.2	0.1	0.3
	Sanatoga	22	1.8	<0.1	0.3
	Philadelphia	25	1.1	<0.1	0.3
	Pittsburgh	24	1.2	<0.1	0.3
	Reading	24	2.1	<0.1	0.4
	Warminster	24	2.9	<0.1	0.4
	West Chester	24	0.8	<0.1	0.3
	York	26	1.4	<0.1	0.4
P.R:	Bayamón	23	2.0	<0.1	0.3
	Guayanilla	20	0.7	<0.1	0.2
	Ponce	21	1.1	<0.1	0.2
	San Juan	24	0.9	<0.1	0.2
R.I:	East Providence	24	0.8	<0.1	0.2
	Providence	26	2.0	0.1	0.4
	Washington County*	26	1.4	0.1	0.4
S.C:	Charleston	25	1.1	0.1	0.3
	Richland County*	20	0.8	<0.1	0.3
	Spartanburg	26	1.3	0.1	0.4
S.Dak:	Black Hills Forest*	26	0.9	<0.1	0.3
	Sioux Falls	26	0.8	<0.1	0.3
Tenn:	Chattanooga	24	1.2	<0.1	0.4
	Knoxville	25	1.2	<0.1	0.3
	Memphis	26	1.1	<0.1	0.3
	Nashville	23	1.0	0.1	0.3
Tex:	Dallas	26	1.8	<0.1	0.4
	Houston	25	1.0	<0.1	0.3
	Matagorda County*	25	1.0	<0.1	0.3
	San Antonio	25	0.6	<0.1	0.3
Utah:	Salt Lake City	26	2.5	0.1	0.5
Vt:	Burlington	25	1.2	<0.1	0.3
	Orange County*	24	1.4	0.1	0.4
Va:	Hampton	25	1.3	0.1	0.3
	Lynchburg	25	1.2	0.1	0.4
	Norfolk	25	1.5	0.1	0.4
	Shenandoah Nat Park*	25	1.2	<0.1	0.4
	Portsmouth	26	0.8	<0.1	0.3
	Richmond	25	1.5	<0.1	0.5
	Roanoke	24	1.0	<0.1	0.4
Wash:	Seattle	26	0.8	<0.1	0.2
W. Va:	Charleston	25	0.8	0.1	0.3
	Weirton	23	1.2	0.1	0.4
	Wheeling	25	1.3	<0.1	0.4
Wis:	Door County*	21	0.8	<0.1	0.3
	Kenosha	25	2.0	0.1	0.4
	Madison	25	1.0	<0.1	0.3
	Milwaukee	25	0.8	<0.1	0.3
Wyo:	Cheyenne	25	1.4	<0.1	0.4
	Yellowstone Park*	24	1.1	<0.1	0.4

* Denotes nonurban station.

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Section IV. Other Data

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included are such data as those obtained from human bone sampling, bovine thyroid sampling, and environmental monitoring reports.

STRONTIUM-90 IN HUMAN BONE, DEATHS THROUGH 1964

Division of Radiological Health, Public Health Service

To obtain data on the concentration of strontium–90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. The target population includes children and young adults up to 25 years of age. Since strontium–90 in measurable amounts has been present in the global environment for more than a decade, and major calcium accretion ceases by age 17 or 18, persons over 25 years old are of limited interest in the program. This has been confirmed by analyses of selected samples of people in older age groups, the results having shown their bone strontium–90 content to be low and age-independent (*1*).

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained post mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally this amount is readily available from older children, but it presents some difficulties from the standpoint of infants and children under 5 years of age.

Most specimens received to date have been vertebrae and ribs. Efforts to collect long bones for comparison to British data have not been successful.

The results of laboratory analyses for strontium–90 in individual bones from persons dying through 1964 which have not previously been published in *Radiological Health Data & Reports* are presented in table 1. All data are summarized in table 2.

The data are reported as picocuries of strontium–90 per gram of ash (the primary determination), per gram of calcium (for comparison with other data and for purposes of model development) and per gram of bone (as a rough indication of dose). Two–sigma counting errors are reported for the ash concentration. Following the pattern of earlier reports (*2–4*), subsequent articles will provide interpretation of the data at appropriate stages in the program.

Table 1. Details of samples and results of analyses

Region, state, and sample number	Age at death [a]			Sex	Date of death			Bone type [b]	Original weight (g)	Ash weight (g)	pCi strontium-90/g of:		
	Yrs	Mo	Day		Yr	Mo	Day				Ash ±2s.d. C.E.	Calcium	Bone
Northeast													
Maine													
I-9(0003)	16	3	29	M	64	3	15	S	277.3	7.7	0.80±0.12	2.49	0.02
Massachusetts													
I-2(0065)	12	5	9	M	64	1	11	V	207.7	24.3	0.69±0.01	1.88	0.08
I-2(0074)	13	4	23	M	64	2	2	V	86.7	7.3	0.87±0.13	2.41	0.07
I-2(0096)	5	11	8	F	64	4	9	V	106.3	9.1	1.00±0.11	2.85	0.09
I-2(0098)	20	8	18	M	64	4	14	V	125.1	17.2	0.96±0.08	2.66	0.13
I-2(0098) [c]	20	8	18	M	64	4	14	V	125.1	17.2	0.43±0.06	1.18	0.06
I-2(0103)	9		13	F	64	5	10	V	164.4	12.8	1.07±0.10	3.11	0.08
I-2(0106)	12	3		F	64	5	21	V	116.9	8.8	0.75±0.11	2.13	0.06
I-2(0113)	13			M	64	6	2	V	119.3	19 8	1.10±0.07	2.97	0.18
I-2(0114)	8	11		M	64	6	6	V	83.7	6.0	0.39±0.10	1.15	0.03
I-2(0115)	15	11	1	M	64	6	23	V	97.1	12.0	0.69±0.08	1.83	0.09
I-2(0117) [c]	12			M	64	6	27	V	139.6	13.5	0.54±0.08	1.50	0.05
I-2(0117)	12			M	64	6	27	V	139.6	13.5	1.14±0.10	3.08	0.11
I-2(0121)	14			M	64	8	2	V	199.0	22.9	1.08±0.06	2.92	0.13
I-2(0124)	10			M	64	8	27	V	85.2	9.1	1.10±0.13	3.04	0.12
I-2(0132)	7	11	19	F	64	9	26	V	109.4	11.0	0.91±0.03	2.48	0.09
I-2(0138)	3	11	6	F	64	11	13	V	87.5	7.3	1.55±0.16	4.48	0.13
I-2(0139)	2	7	22	M	64	11	16	V	67.5	5.6	1.83±0.24	5.39	0.15
I-2(0140)	6	10	17	F	64	12	8	V	85.2	9.7	1.90±0.15	5.19	0.22
I-2(0108)	2	10	6	M	64	5	24	V	105.6	7.4	2.25±0.18	6.42	0.16
I-2(0109)	8			F	64	5	27	V	220.4	16.9	0.89±0.08	2.49	0.07
I-2(0110)	5	6	6	F	64	5	29	V	138.0	10.6	1.42±0.12	3.96	0.11
I-7(0006)	21	5	3	M	64	12	12	V	89.5	14.5	0.81±0.08	2.12	0.13
I-7(0006) [c]	21	5	3	M	64	12	12	V	89.5	14.5	0.75±0.08	1.98	0.12
I-8(0026)	25	3	20	F	64	11	27	V	76.6	7.5	1.13±0.13	2.99	0.11
I-8(0027)	24			M	64	12	21	V	86.1	10.6	0.44±0.07	1.22	0.06
I-15(0001)	22	4	24	M	64	10	4	V	125.0	17.0	0.64±0.06	1.68	0.09
New Jersey													
II-36(0005)	8	7	18	M	64	5	9	V	163.2	19.3	1.10±0.08	3.11	0.13
New York													
II-10(0009)	19	1	12	M	63	5	5	V	169.5	19.8	0.60±0.07	1.65	0.07
II-10(0011)	14	2	25	F	63	5	27	V	156.5	18.1	0.57±0.07	1.54	0.07
II-10(0012)	24	2	14	M	63	6	10	V	168.6	17.8	0.65±0.08	1.73	0.07
II-10(0013)	23	1	24	M	63	7	28	V	94.3	14.0	1.01±0.11	2.70	0.15
II-10(0014)	17	11	24	F	63	7	28	V	177.6	21.2	0.80±0.08	2.14	0.10
II-10(0015)	15	1	12	M	63	7	28	V	163.5	19.7	0.83±0.08	2.28	0.10
II-10(0016)	18	5	27	M	63	8	14	V	151.8	22.1	0.78±0.08	2.07	0.11
II 10(0017)	17	5	29	M	63	8	14	V	143.0	22.2	1.00±0.09	2.59	0.16
II-10(0019)	22	9	21	M	63	11	17	V	179.6	24.0	0.91±0.08	2.38	0.12
II-10(0020)	19	5	10	M	63	11	20	V	166.3	12.4	0.90±0.12	2.44	0.07
II-10(0023)	25	3	9	M	64	3	3	V	149.8	19.9	0.43±0.05	1.15	0.06
II-10(0024)	24	1	13	M	64	3	11	V	139.8	17.7	0.77±0.07	2.07	0.10
II-12(0015)	23	7	7	M	64	2	24	V	180.9	20.2	0.46±0.05	1.28	0.05
II-12(0016)	19	3	7	M	64	3	3	V	171.0	18.0	0.71±0.07	1.88	0.08
II-23(0003)	21	2	15	M	64	4	19	V	113.6	13.2	0.68±0.07	1.83	0.04
II-23(0003)	21	2	15	M	64	4	19	V	113.6	13.2	0.59±0.07	1.55	0.07
II-23(0005)	11	7	3	M	64	6	24	V	219.8	20.9	0.86±0.06	2.41	0.08
II-23(0006)	18	11		M	64	7	19	V	167.2	21.8	0.65±0.05	1.70	0.09
II-23(0008)	19	6	20	M	64	7	25	V	148.2	19.8	0.60±0.06	1.61	0.08
II-23(0009)	18	3	22	F	64	8	16	V	136.8	21.4	0.85±0.06	2.24	0.13
II-23(0010)	18	2	24	M	64	8	28	V	106.9	14.8	0.87±0.08	2.32	0.06
II-23(0010)	18	2	24	M	64	8	28	V	106.9	14.7	0.79±0.07	2.20	0.11
II-23(0011)	15	2	26	M	64	9	13	V	213.0	22.5	0.98±0.07	2.71	0.10
II-23(0012)	17	4	17	M	64	9	24	V	117.9	15.9	1.18±0.09	3.12	0.16
II-23(0013)	5	8	20	M	64	10	11	V	104.5	9.1	0.97±0.11	2.78	0.08
II-23(0016)	17		2	M	64	11	26	V	97.9	14.4	1.11±0.09	2.92	0.16
II-23(0017)	23	6		M	64	12	15	V	123.7	16.3	0.79±0.07	2.12	0.10
II-23(0018)	23	1	11	F	64	12	17	V	159.5	23.3	0.51±0.05	1.37	0.08
II-31(0001)	16	10	4	M	64	9	7	V	164.8	17.8	0.96±0.08	2.58	0.10
II-38(0006)	15	7	7	M	64	2	25	V	110.4	13.7	1.31±0.10	3.50	0.16
II-38(0006)	15	7	7	M	64	2	25	V	110.4	13.7	1.10±0.09	3.01	0.14
II-38(0007)	8	3	10	M	64	3	1	V	162.0	14.4	0.83±0.08	2.36	0.07
II-38(0008)	7	1	3	F	64	3	3	V	143.6	16.0	0.93±0.08	2.46	0.10
II-38(0009)	9	4	22	F	64	3	10	V	190.1	17.5	0.83±0.07	2.31	0.08
II-38(0013)	5	3	1	M	64	4	1	V	158.1	12.0	1.00±0.09	2.83	0.08
II-38(0014)	16	10	21	M	64	4	20	V	79.7	13.9	0.69±0.07	1.81	0.12
II-38(0016)	8	7	3	F	64	4	29	V	147.8	14.6	0.75±0.07	2.03	0.07
II-38(0017)	4	8	14	F	64	5	4	V	152.2	10.3	1.07±0.15	3.23	0.07
II-38(0018)	21	7	17	F	64	5	5	V	166.1	17.5	0.29±0.04	0.76	0.03
II-38(0019)	15	8	7	F	64	5	6	V	183.0	25.1	0.46±0.04	1.25	0.06
II-38(0020)	13	5	27	M	64	5	13	V	160.7	12.6	0.79±0.08	2.13	0.06
II-38(0024)	23	4	17	F	64	6	16	V	159.6	21.5	0.42±0.04	1.12	0.06
II-38(0025)	4		5	M	64	6	28	V	137.0	13.7	1.47±0.11	4.02	0.15

Table 1—Continued

Region, state, and sample number	Age at death [a]			Sex	Date of death			Bone type [b]	Original weight (g)	Ash weight (g)	pCi strontium-90/g of:		
	Yrs	Mo	Day		Yr	Mo	Day				Ash ±2s.d. C.E.	Calcium	Bone
New York—Continued													
II-38(0026)	4	6	20	F	64	7	7	V	141.7	11.4	0.94±0.03	2.55	0.08
II-38(0027)	18		14	F	64	7	17	V	163.1	24.8	0.83±0.06	2.19	0.13
II-38(0028)	22		12	F	64	7	21	V	167.9	17.3	0.81±0.07	2.21	0.08
II-38(0029)	23	7	29	F	64	7	23	V	172.6	14.9	0.46±0.06	1.26	0.04
II-38(0030)	3	1	15	F	64	7	26	V	112.3	9.3	1.71±0.13	4.60	0.14
II-38(0031)	4	9	2	M	64	7	29	V	147.8	14.7	1.59±0.10	4.34	0.16
II-38(0032)	7	6	21	M	64	8	22	V	168.8	17.3	0.92±0.07	2.68	0.09
II-38(0033)	13		24	F	64	8	28	V	162.7	21.8	1.14±0.07	3.01	0.15
II-38(0035)	10	4	15	M	64	9	17	V	140.8	12.2	1.29±0.12	3.63	0.11
II-38(0037)	24	11	6	F	64	10	27	V	165.9	15.4	0.64±0.07	1.70	0.06
II-38(0039)	11	5	29	M	64	12	9	V	160.4	13.4	0.72±0.08	2.04	0.06
II-38(0040)	4	4	28	M	64	12	25	V	134.2	14.8	0.97±0.09	2.65	0.11
II-38(0041)	15		7	F	64	12	28	V	169.6	21.5	0.47±0.05	1.23	0.06
II-39(0002)	3	10	8	M	64	8	31	V	136.6	15.5	1.43±0.09	3.83	0.16
Pennsylvania													
II-3(0003)	5		13	M	63	8	1	V	113.7	12.8	1.17±0.13	3.37	0.13
II-3(0005)	24	2	25	M	63	8	11	V	93.5	16.3	0.67±0.09	1.76	0.12
II-3(0008)	18	2	28	M	64	3	5	V	175.4	21.6	0.91±0.10	2.44	0.11
II-4(0020)	24	11	21	M	64	1	25	V	185.5	14.1	0.51±0.06	1.46	0.04
II-4(0023)	19	5	8	M	64	3	25	V	150.6	16.5	0.71±0.06	1.93	0.08
II-4(0026)	13	4	24	F	64	4	15	V	132.7	14.4	0.64±0.06	1.76	0.07
II-4(0029)	6	8	4	M	64	7	11	V	95.1	8.1	0.98±0.11	2.81	0.08
II-4(0031)	24	1	27	M	64	9	30	V	122.1	10.5	0.57±0.08	1.59	0.05
II-19(0043)	20	4	4	M	63	7	13	R, V	150.1	23.1	0.69±0.07	1.79	0.11
II-19(0046)	22	4	18	M	63	7	27	V	93.4	15.9	0.62±0.09	1.64	0.11
II-19(0047)	19	5	28	M	63	8	1	V	126.4	18.5	0.85±0.08	2.34	0.13
II-19(0049)	25	6	28	M	63	8	24	V	94.8	14.9	0.70±0.09	1.94	0.05
II-19(0050)	5	7	8	M	63	9	9	V	103.7	8.5	1.54±0.17	4.67	0.13
II-19(0052)	24	5	21	M	63	10	22	V	136.8	18.2	1.03±0.10	2.72	0.14
II-19(0063)	14	6	5	M	64	4	21	V	121.1	13.5	0.70±0.07	2.02	0.08
Vermont													
I-6(0040)	25	1	26	M	64	4	30	V	133.9	18.2	0.67±0.06	1.74	0.09
I-6(0040)	25	1	26	M	64	4	30	V	133.9	18.2	0.59±0.06	1.62	0.08
I-6(0050)	22	9	25	F	64	11	14	V	100.8	17.0	0.67±0.07	1.76	0.11
I-6(0050)	22	9	25	F	64	11	14	V	100.8	17.0	0.81±0.08	2.09	0.14
I-6(0052)	15	1	14	M	64	12	29	V	101.1	14.3	1.66±0.11	4.56	0.24
I-6(0052)	15	1	14	M	64	12	29	V	101.1	14.3	1.80±0.12	4.70	0.25
I-13(0005)	6	10	21	F	64	8	14	V	207.6	20.0	0.89±0.06	2.51	0.09
Southeast													
Kentucky													
III-10(0001)	10	6	23	F	63	8	10	R, V	122.4	17.9	0.87±0.09	2.24	0.13
III-10(0001)	10	6	23	F	63	8	10	R, V	122.4	17.9	0.87±0.10	2.34	0.13
III-10(0002)	14	7	19	F	64	7	15	V	181.6	22.4	0.82±0.06	2.33	0.10
III-10(0002)	14	7	19	F	64	7	15	V	181.6	22.4	0.89±0.06	2.43	0.11
III-10(0003)	24	5	8	F	64	9	9	V	122.9	19.2	0.80±0.07	2.10	0.13
III-10(0003)	24	5	8	F	64	9	9	V	122.9	19.2	0.69±0.05	1.86	0.11
III-10(0003)	24	5	8	F	64	9	9	V	122.9	19.2	0.82±0.06	2.19	0.13
Maryland													
III-6(0001)	9		28	M	63	6	2	V	137.2	10.0	0.82±0.15	3.55	0.06
III-7(0024)	18	2	2	M	63	4	6	V	100.5	14.1	0.74±0.09	1.95	0.10
III-7(0024)	18	2	2	M	63	4	6	V	100.5	14.1	0.87±0.10	2.26	0.12
III-7(0025)	17	1	6	M	63	5	12	V	150.1	19.4	0.76±0.08	2.02	0.10
III-7(0026)	22		25	M	63	4	4	V	130.8	16.3	0.66±0.10	1.73	0.08
III-7(0027)	15	1	2	M	63	6	6	V	219.0	27.3	1.02±0.08	2.72	0.13
III-7(0028)	20		6	M	63	4	30	V	174.4	24.3	0.62±0.07	1.66	0.09
III-7(0029)	20	3	21	M	63	5	23	V	97.2	16.2	0.71±0.08	1.86	0.12
III-7(0029)	20	3	21	M	63	5	23	V	97.2	16.2	0.80±0.11	2.06	0.13
III-7(0030)	14		26	F	63	4	3	V	137.7	19.2	0.75±0.08	1.99	0.10
III-7(0031)	13	6	24	M	63	5	8	V	149.6	16.9	1.17±0.10	3.21	0.13
III-7(0036)	24			M	63	4	21	V	123.7	15.6	0.46±0.07	1.18	0.06
III-7(0036) [c]	24			M	63	4	21	V	123.7	15.6	0.59±0.07	1.56	0.07
III-7(0037)	19	9	20	F	63	5	14	V	157.0	21.5	1.04±0.09	2.75	0.14
III-7(0038)	25	6	23	M	63	5	23	V	200.8	25.7	0.94±0.06	1.27	0.06
III-7(0039)	19		5	M	63	5	18	V	181.3	24.9	0.74±0.07	1.34	0.10
North Carolina													
III-13(0014)	19	4	21	M	64	3	3	V	139.2	16.3	1.00±0.07	2.74	0.12
Virginia													
III-5(0002)	6	8	7	M	63	5	28	R, V	108.7	9.9	1.81±0.22	4.95	0.16
Central													
Illinois													
V-27(0002)	18	11	27	M	64	4	13	V	137.4	17.5	0.41±0.05	1.08	0.05
V-27(0002) [c]	18	11	27	M	64	4	13	V	137.4	17.5	0.50±0.05	1.30	0.06
V-27(0002) [d]	18	11	27	M	64	4	13	V	137.4	17.5	0.40±0.05	1.05	0.05
V-27(0003)	19	6	25	M	64	9	5	V	98.8	12.7	0.60±0.07	1.60	0.08
V-27(0003) [e]	19	6	25	M	64	9	5	V	98.8	12.7	0.59±0.07	1.60	0.08

Table 1—Continued

Region, state, and sample number	Age at death [a]			Sex	Date of death			Bone type [b]	Original weight (g)	Ash weight (g)	pCi strontium-90/g of:		
	Yrs	Mo	Day		Yr	Mo	Day				Ash ±2s.d. C.E.	Calcium	Bone
Illinois—continued													
V-27(0005)	20	1	14	M	64	12	28	R	95.3	20.0	0.37±0.04	0.97	0.08
Michigan													
V-5(0008)	20			F	64	8	29	V	137.8	16.1	0.62±0.06	1.67	0.07
V-6(0002)	2	8	26	M	64	6	24	V	142.6	14.6	1.18±0.09	3.19	0.12
V-6(0003)	22	6	18	M	64	12	15	V	167.1	24.2	0.68±0.06	1.75	0.10
Minnesota													
VI-6(0004)	15	4		F	62	11	18	R,V,S	176.9	26.0	0.74±0.13	2.46	0.14
VI-16(0001)	10	4	5	F	63	11	12	V	221.0	23.6	1.53±0.10	4.07	0.16
VI-16(0003)	19	5	29	F	64	10	6	V	140.7	12.3	1.02±0.10	2.71	0.09
VI-19(0005)	16	10	2	M	64	2	2	V	163.3	18.7	0.60±0.06	1.66	0.07
VI-19(0006)	4	5	3	F	64	2	14	V	115.9	9.2	0.80±0.11	2.21	0.06
VI-19(0008)	20	8	24	F	64	2	25	V	93.5	10.9	0.69±0.10	1.76	0.08
VI-19(0011)	7	4	16	F	64	3	24	V	146.0	14.3	0.83±0.09	2.27	0.08
VI-19(0014)	9	1	11	M	64	5	9	V	109.8	10.1	2.17±0.16	6.04	0.20
VI-19(0015)	23			M	64	5	22	V	177.1	23.2	0.90±0.06	2.35	0.12
VI-19(0017)	11	5	16	F	64	6	9	V	150.6	14.3	0.67±0.07	1.83	0.06
VI-19(0019)	18	2	9	M	64	8	18	V	121.4	19.5	0.60±0.02	1.59	0.10
VI-19(0022)	9	7	16	F	64	9	10	V	145.9	12.0	0.93±0.11	2.53	0.08
VI-19(0023)	7	1	8	M	64	10	6	V	128.9	12.5	2.21±0.04	6.03	0.22
VI-19(0039)	17	6	2	M	64	12	8	V	181.8	20.2	0.75±0.06	2.01	0.08
VI-19(0040)	8	11	29	F	64	12	29	V	134.7	10.5	1.56±0.12	4.28	0.12
VI-19(0041)	18			M	64	12	21	V	140.9	13.5	0.63±0.07	1.73	0.06
VI-19(0041)*	18			M	64	12	29	V	140.9	13.5	0.57±0.07	1.53	0.06
Missouri													
VI-7(0032)	22	8	11	F	64	10	8	V	159.2	6.6	0.50±0.09	1.91	0.02
Ohio													
V-19(0086)	4	11	1	F	63	1	27	V	155.8	17.7	0.63±0.09	1.68	0.07
V-19(0123)	4	7	11	M	64	1	3	V	118.1	11.5	1.25±0.12	3.45	0.12
V-19(0137)	3	7	9	F	64	2	21	V	130.2	8.6	1.05±0.11	3.13	0.07
V-19(0141)		5	1	F	64	3	12	V	55.6	5.3	1.96±0.23	5.65	0.19
V-19(0161)	3	3	9	F	64	4	23	V	48.9	4.1	1.64±0.21	4.33	0.14
V-19(0162)	1	9	13	M	64	4	30	V	54.3	4.1	2.00±0.24	5.34	0.15
V-19(0166)	7	4	7	F	64	5	12	V	88.2	7.3	2.18±0.18	6.24	0.18
V-19(0172)	0	6		F	64	7	4	V	80.1	6.6	2.20±0.20	6.43	0.18
V-19(0177)	1	10	25	M	64	7	17	V	76.2	4.7	1.88±0.20	5.33	0.12
V-19(0181)	2	4	11	M	64	7	27	V	98.7	6.3	2.57±0.20	7.52	0.16
V-19(0185)	2	1	3	F	64	8	7	V	74.6	6.5	3.19±0.22	8.73	0.28
V-19(0186)	4	4	29	F	64	8	10	V	73.6	7.8	1.48±0.15	4.02	0.16
V-19(0188)	1	1	2	M	64	7	25	V	74.7	6.3	2.14±0.21	6.19	0.18
V-19(0189)	6		28	M	64	8	3	V	170.4	14.7	2.15±0.13	6.11	0.19
V-19(0200)	14	4	10	F	64	10	3	V	86.6	12.8	0.99±0.09	2.72	0.15
V-19(0200)*	14	4	10	F	64	10	3	V	86.6	12.8	1.05±0.09	2.77	0.16
V-19(0206)	5	6	24	F	64	8	16	V	83.6	9.8	1.27±0.13	3.43	0.15
V-19(0207)	2	3	24	F	64	10	30	V	71.9	5.9	2.50±0.28	7.10	0.21
V-19(0208)	2		15	M	64	11	29	V	47.5	3.5	1.01±0.22	3.06	0.07
V-19(0209)	3	6	21	F	64	11	26	V	93.9	8.5	2.25±0.17	6.53	0.20
V-19(0210)	1		24	F	64	10	11	V	48.3	5.2	2.45±0.23	7.17	0.26
V-19(0211)			1	F	64	11	23	V	56.2	4.5	0.81±0.17	2.50	0.06
V-19(0214)	1	10	8	F	64	10	17	V	50.7	5.4	2.76±0.23	8.21	0.29
V-19(0219)	6	4	19	F	64	9	1	V	114.3	9.8	1.08±0.11	3.04	0.09
V-26(0005)	23	2	13	M	64	5	24	V	91.3	13.9	0.61±0.12	1.59	0.09
V-31(0001)	7	7		M	64	2	21	V	200.2	22.0	0.67±0.05	1.71	0.07
Wisconsin													
V-03(0042)	3	6	8	M	63	6	2	V	156.8	14.2	1.08±0.13	3.04	0.10
V-03(0044)	8	2	2	F	63	6	25	V	225.7	23.3	0.67±0.07	1.81	0.67
V-03(0051)	5	4	29	M	63	8	6	V	215.7	22.2	1.16±0.09	3.17	0.12
V-03(0053)	9	6	24	M	63	8	3	V	178.4	14.7	0.76±0.11	2.09	0.07
V-03(0053)*	9	6	24	M	63	8	3	V	178.4	14.7	0.67±0.09	2.21	0.06
V-03(0055)	3	5	17	M	63	7	31	V	155.9	12.8	1.76±0.15	4.97	0.14
V-03(0062)		4	11	M	63	9	9	V	313.5	19.4	0.33±0.05	0.96	0.02
V-03(0063)	14	2		M	63	9	12	V	153.9	16.1	1.26±0.11	3.52	0.14
V-03(0063)*	14	2		M	63	9	12	V	153.9	16.1	1.69±0.12	3.75	0.18
V-03(0067)	4	8	14	F	63	9	24	V	119.2	11.0	1.36±0.15	3.93	0.13
V-03(0068)	4	11		F	63	10	2	V	155.8	14.7	1.10±0.11	3.12	0.10
V-03(0069)	3	11	1	M	63	10	7	V	210.6	18.7	1.12±0.10	3.16	0.10
V-03(0070)	15	8	11	F	63	10	8	V	156.5	15.1	0.74±0.12	2.09	0.07
V-03(0070)*	15	8	11	F	63	10	8	V	156.5	15.1	0.79±0.09	2.15	0.08
V-03(0079)	4	5	18	F	63	11	14	V	131.8	13.0	1.69±0.15	4.60	0.17
V-03(0081)	4	11	7	M	63	11	22	V	188.2	15.0	1.40±0.12	4.04	0.11
V-03(0082)	2	5	2	M	63	11	25	V	128.2	12.3	2.03±0.18	5.49	0.20
V-03(0084)	12	11	23	M	63	11	29	V	237.4	23.9	0.59±0.07	1.59	0.06
V-03(0093)	6	6	17	M	64	1	7	V	154.6	14.1	1.19±0.09	3.27	0.11
V-03(0095)	3	5	13	M	64	1	5	V	158.4	13.2	0.63±0.07	1.73	0.05
V-03(0097)	3	9	3	M	64	1	22	V	144.3	16.3	1.25±0.12	3.37	0.14
V-03(0101)	2	9	29	F	64	1	24	V	148.7	11.9	1.09±0.10	3.17	0.09

Table 1—Continued

Region, state, and sample number	Age at death [a]			Sex	Date of death			Bone type[b]	Original weight (g)	Ash weight (g)	pCi strontium-90/g of:		
	Yrs	Mo	Day		Yr	Mo	Day				Ash ±2s.d. C.E.	Calcium	Bone
V-03(0102)	10	11	26	F	64	1	28	V	222.5	21.9	0.96±0.07	2.70	0.09
V-03(0103)		7	8	F	64	2	6	V	130.0	11.2	0.93±0.09	2.67	0.08
V-03(0109)	2	2	10	M	64	2	15	V	106.5	8.8	1.60±0.15	4.35	0.13
V-03(0110)	3	1	28	M	64	2	26	V	118.0	9.8	1.40±0.12	3.95	0.12
V-03(0118)	2	5	18	M	64	4	2	V	160.3	14.8	1.09±0.09	3.04	0.10
V-03(0123)	3	5	13	M	64	4	17	V	165.8	16.2	1.34±0.10	3.68	0.13
V-03(0125)	7	8	17	F	64	4	19	V	125.1	11.4	0.74±0.09	2.03	0.07
V-03(0126)	14	5	29	M	64	4	19	V	175.2	22.4	1.05±0.07	2.76	0.13
V-03(0126) [c]	14	5	29	M	64	4	19	V	175.2	22.4	0.93±0.06	2.61	0.12
V-03(0134)	4	4	27	M	64	5	27	V	141.8	13.8	0.74±0.08	1.99	0.07
V-03(0137)	4	2	6	M	64	6	12	V	103.6	10.1	1.02±0.10	2.84	0.10
V-03(0145)	3	5	18	M	64	7	17	V	157.0	14.1	1.28±0.09	3.51	0.12
V-03(0152)	16	2	2	F	64	9	29	V	202.4	17.3	0.84±0.07	2.19	0.11
V-03(0152) [c]	16	2	2	F	64	9	29	V	202.4	17.3	0.72±0.06	1.94	0.09
V-03(0152) [d]	16	2	2	F	64	9	29	V	134.9	17.3	0.84±0.08	2.28	0.11
V-03(0182)	8	4	11	M	64	12	30	V	200.1	19.2	1.41±0.08	3.86	0.14
Louisiana													
VII-8(0014)	21	1	6	M	63	10	10	V	115.1	18.7	0.88±0.07	2.36	0.14
VII-8(0014) [c]	21	1	6	M	63	10	10	V	115.1	18.7	0.98±0.07	2.49	0.16
VII-8(0015)	2	3	28	M	63	11	9	R, V	149.4	15.6	1.93±0.13	5.24	0.20
VII-8(0018)	21			M	63	12	26	V	122.3	18.1	0.70±0.06	1.83	0.10
VII-8(0018) [c]	21			M	63	12	26	V	122.3	18.1	0.57±0.03	1.55	0.09
VII-8(0024)	24	5	18	M	64	4	4	V	104.5	16.2	0.54±0.06	1.44	0.09
VII-8(0024) [c]	24	5	18	M	64	4	4	V	104.5	16.2	0.57±0.07	1.49	0.09
VII-8(0036)	18	8	25	F	64	10	20	V	175.4	19.9	1.45±0.09	3.86	0.16
VII-8(0037)	11	11	6	M	64	11	15	V	166.2	19.2	1.26±0.08	3.45	0.15
VII-8(0038)	23	1	22	M	64	12	27	V	99.9	17.7	1.14±0.09	3.12	0.02
VII-8(0038) [c]	23	1	22	M	64	12	27	V	99.9	17.7	1.04±0.07	2.83	0.19
VII-8(0038) [d]	23	1	22	M	64	12	27	V	99.9	17.7	1.06±0.08	2.57	0.19
VII-8(0039)	7	9	20	F	64	12	28	V	179.0	13.8	1.55±0.11	4.48	0.12
Tennessee													
IV-9(0013)	12	5		F	63	12	29	V	137.1	22.0	1.11±0.11	2.83	0.18
IV-14(0005)	20	9		M	63	3	27	V	240.1	32.0	0.90±0.09	2.34	0.12
IV-14(0007)	20	6	13	M	63	12	6	R, V	132.7	16.9	0.55±0.06	1.47	0.07
IV-14(0007) [c]	20	6	13	M	63	12	6	R, V	132.7	16.9	0.65±0.07	1.74	0.08
Southwest													
Arizona													
IX-27(0002)	5	7	25	F	64	3	29	V	123.9	10.4	0.93±0.14	2.50	0.08
California													
IX-8(0032)			1	M	64	11	18	R,V,S	106.2	10.6	0.35±0.07	0.96	0.18
IX-9(0012)	23	8	26	M	63	3	13	V	176.6	23.3	0.32±0.05	0.84	0.04
IX-9(0012) [c]	23	8	26	M	63	3	13	V	176.6	23.3	0.99±0.19	1.34	0.07
IX-17(0002)	23	7	20	M	63	10	26	V	138.7	15.1	0.94±0.10	2.52	0.10
IX-17(0002) [c]	23	7	20	M	63	10	26	V	138.7	15.1	1.02±0.11	2.84	0.11
IX-31(0003)	24		10	M	64	4	11	V	127.0	17.1	0.58±0.06	1.55	0.08
Colorado													
VIII-3(0005)	23	2	4	M	63	7	25	S	231.8	13.1	0.64±0.10	1.72	0.04
VIII-4(0002)	5	11	7	M	62	11	21	V	118.5	11.4	0.36±0.02	1.00	0.03
Texas													
VII-4(0002)	8	9		F	64	7	4	V	79.4	11.0	0.50±0.08	1.37	0.07
VII-4(0003)	11	3	28	M	64	7	6	V	89.4	9.5	1.07±0.12	2.94	0.11
VII-4(0004)	3	6	27	F	64	8	11	V	130.7	7.3	1.58±0.16	4.99	0.09
VII-4(0006)	16	8	16	M	64	9	19	V	131.0	14.4	0.74±0.07	2.02	0.08
VII-5(0001)	13	5	12	M	62	10	7	V	178.7	18.9	0.75±0.10	1.89	0.08
VII-5(0002)	11	8	20	F	63	1	29	V	160.8	16.8	0.67±0.08	1.83	0.07
VII-11(0005)	18			M	63	11	15	R, V	107.0	13.4	0.67±0.06	1.77	0.08
VII-11(0005) [c]	18			M	63	11	15	R, V	107.0	13.4	0.69±0.09	1.85	0.09
VII-12(0004)	14	11	7	F	64	12	23	V	119.5	15.0	0.34±0.06	0.90	0.04
VII-17(0014)	25		15	M	64	5	8	V	122.0	15.6	0.53±0.06	1.45	0.07
VII-17(0015)	11			M	64	10	29	T,FB	123.2	20.6	0.94±0.07	2.34	0.16
Northwest													
Alaska													
IX-29(0001)	23	5	24	M	64	4	19	R	97.3	27.8	0.24±0.03	0.62	0.07
IX-29(0002)	2	1	25	F	64	6	19	R	15.3	4.0	1.26±0.20	3.23	0.33
Washington													
IX-7(0022)	4	9	23	F	63	6	17	V	124.9	9.6	1.32±0.14	3.88	0.10

[a] Or time of surgical procedure.
[b] R, rib; V, vertebra; S, sternum; FM, femur; T, tibia; FB, fibula.
[c] Duplicate analysis.
[d] Replicate analysis.

Table 2. Summary of results

Age group and year of death [b]	Number	pCi ^{90}Sr/g calcium [a]		
		Mean	Minimum	Maximum
0–4 years				
1961	3	2.7	1.8	3.4
1962	50	3.3	0.8	9.7
1963	44	4.5	1.0	13.0
1964	67	4.4	1.0	8.7
5–9 years				
1961	1	2.7	2.7	2.7
1962	33	2.7	1.0	9.4
1963	43	3.9	1.8	9.1
1964	64	3.6	1.2	7.0
10–14 years				
1961	4	1.8	1.2	2.8
1962	28	2.1	0.8	3.5
1963	47	2.9	1.1	9.0
1964	56	3.1	0.9	5.7
15–19 years				
1961	0			
1962	31	2.2	0.9	4.6
1963	73	2.6	1.0	7.0
1964	58	2.9	1.2	6.1
20–25 years				
1961	0			
1962	29	1.8	0.9	3.5
1963	61	2.2	0.9	5.0
1964	52	2.2	0.8	4.3
Total samples				
1961	8			
1962	171			
1963	268			
1964	297			

[a] Includes all data through 1964.
[b] Or surgical procedure.

Laboratory procedures

The samples are analyzed at the Northeastern Radiological Health Laboratory of the Division of Radiological Health, at Winchester, Massachusetts. An yttrium fraction is separated from the bone ash by extraction with 2–thenoyltrifluoroacetone (TTA). The strontium–90 content is then calculated (*2,3*) from the yttrium–90 activity. "Blind" duplicate analyses are performed on 10 to 20 percent of the samples. In addition, pools of animal bone ash and adult human bone ash are analyzed in replicate on a continuing basis.

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(*1*) RIVERA, J. Strontium-90 in human vertebrae, 1962–1963. Rad Health Data 5:511–513 (October 1964).

(*2*) WEISS, E. S., W. H. LAND, K. H. FALTER, and R. M. HALLISEY. Strontium-90 content of human bones, 1961–1963. Rad Health Data 5:231–239 (May 1964).

(*3*) NORTHEASTERN RADIOLOGICAL HEALTH LABORATORY, PUBLIC HEALTH SERVICE. Analysis of environmental samples chemical and radiochemical procedures. NERHL 64–1 (April 1964).

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ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semi-annual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Bettis Atomic Power Laboratory, the Feed Materials Production Center, Knolls Atomic Power Laboratory, and S1C Prototype Reactor Facility.

[1] Part 20, "Standards for Protection Against Radiation," AEC Rules and Regulations, contains essentially the standards published in the "AEC Manual." The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, on a subscription basis at $3.50 for 3 years.

1. Bettis Atomic Power Laboratory January–June 1965[2]

Westinghouse Electric Corporation
Pittsburgh, Pennsylvania

The Bettis Atomic Power Laboratory (BAPL), operated for the Atomic Energy Commission by the Westinghouse Electric Corporation, was established in 1949 to conduct research and development operations related to naval atomic propulsion systems and to the central station power reactor at Shippingport, Pennsylvania. Routine environmental monitoring data from the sampling locations shown in figure 1 indicate that environmental radiation concentrations resulting from laboratory operations are well within Atomic Energy Commission prescribed limits.

Liquid radioactive waste

Liquid effluent discharged from the Laboratory is sampled continuously. Composite samples are analyzed weekly for gross alpha and gross beta–gamma activity, and quarterly for strontium–90 activity.

The average concentration of gross beta radioactivity in the liquid effluent during the first 6 months of 1965 was 3,000 pCi/liter. This was considerably higher than the average concentration of 180 pCi/liter observed in the second half of 1964, although it remained well below the limits prescribed by the AEC. The average concentrations of strontium–90 for the fourth quarter of 1964 and the first and second quarters of 1965 were 36 pCi/liter, 84 pCi/liter, and 140 pCi/liter, respectively.

Background monitoring stations

Beta–gamma background radiation levels are continuously monitored and recorded at monitoring stations located at the periphery of the laboratory property. Average readings at these stations are summarized in table 1.

Beta–gamma radiation intensities averaged 0.022 mR/hr during this period. This average is not significantly different from the background radiation intensities measured during

[2] Summarized from "Environmental Radioactivity at the Bettis Atomic Power Laboratory for the First Six Months of 1965," Semiannual Report PNRO–DEV–134, issued July 16, 1965.

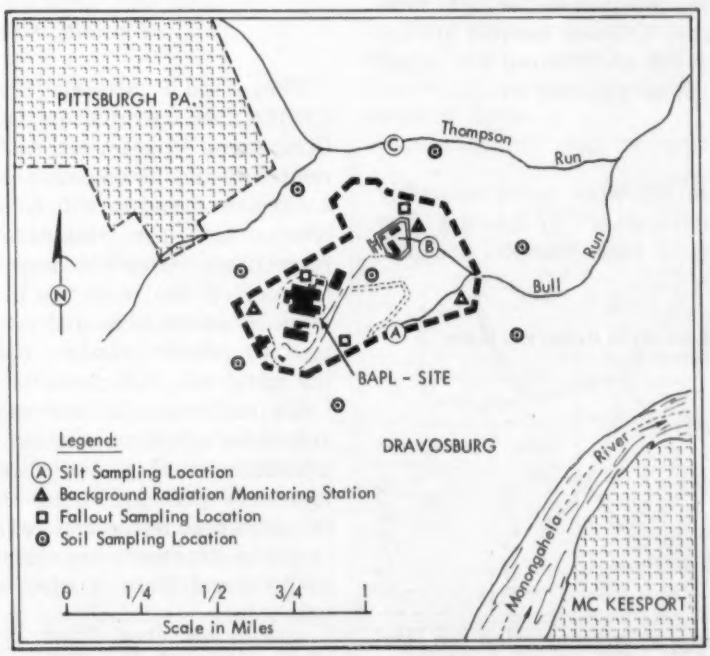

Figure 1. Bettis Atomic Power Laboratory sampling stations

Table 1. Beta-gamma radiation, Bettis January–June 1965

Measurements	Average levels, mR/hr		
	Station 1	Station 3	Station 4
High weekly level	0.044	0.060	0.394
Low weekly level	0.012	0.010	0.010
Mean	0.016	0.012	0.038

the second 6 months of 1964. The higher background radiation levels at station #4 are due to the proximity of the environmental monitoring detector to the C-area critical test facility.

Fallout

Fallout samples are collected at three locations at the perimeter of the laboratory. Samples are collected over a period of 1 month in high-wall stainless-steel pots, and are analyzed for gross beta activity. The average monthly concentration of radioactive fallout for the first half of 1965 was 3.86 nCi/m^2. There was no significant change in fallout activity during this period as compared to the last 6 months of 1964.

Soil samples

Soil samples were collected at the eight locations shown in figure 1. These samples are not analyzed routinely but are retained for future analysis to establish background levels.

Stream silt

Stream silt samples were taken quarterly at the three locations shown in figure 1. The results of analysis of these samples are presented in table 2.

Table 2. Radioactivity in stream silt, Bettis January–June 1965

Period	Location	pCi/g of silt	
		Alpha	Beta-gamma
First quarter, 1965	A	19	14
	B	15	14
	C	41	220
Average		25	83
Second quarter, 1965	A	67	220
	B	12	17
	C	17	25
Average		32	87

The average alpha concentration on the stream silt samples was approximately the same as the average alpha concentration for these locations during the second six months of 1964. The average beta–gamma concentration is significantly increased over the average for the second 6 months of 1964. This was due to a higher concentration in the plant liquid effluent being discharged at location A. Beta–gamma results for the first quarter from location C are considered to be in error since the liquid effluent concentration during this period was lower than the previous period.

Recent coverage in *Radiological Health Data:*

Period	Issue
July 1961–June 1962	April 1963
July 1962–June 1963	April 1964
July 1963–December 1963	November 1964
January–June 1964	April 1965
July–December 1964	October 1965

2. Feed Materials Production Center January–June 1965[3]

National Lead Company
Fernald, Ohio

The Feed Materials Production Center (FMPC) is operated by the National Lead Company of Ohio for the AEC. The location as related to populated areas is shown in figure 2. Cincinnati and Hamilton—the larger nearby communities—are situated 20 and 10 miles, respectively, from the center. Operations at this project deal with the processing of high-grade uranium ores and ore concentrates to produce metallic uranium, and with fabricating the metal into fuel elements.

An environmental survey program of air and water sampling is maintained to check the effectiveness of dust collectors and waste treatment processes. Inspection of the data indicates that releases of radioactive materials to the environment are controlled as required by AEC and State of Ohio regulations.

[3] Summarized from "Feed Materials Production Center Environmental Monitoring Semi-Annual Report for the First Half of 1965" (NLCO–958).

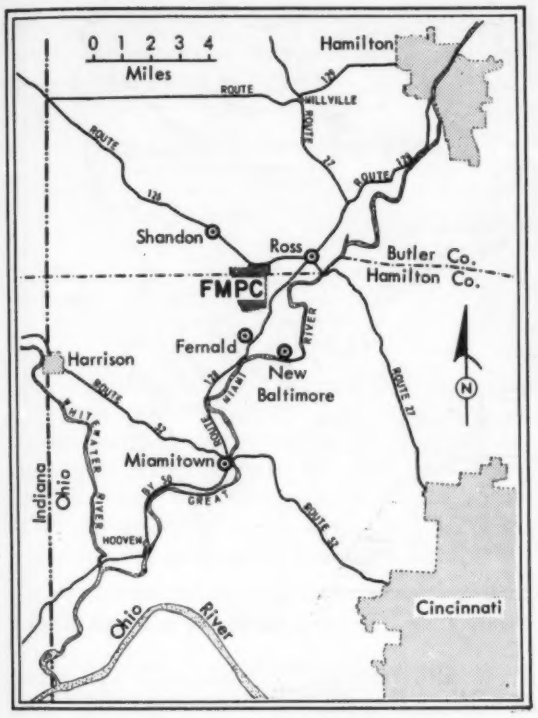

Figure 2. Area map of Feed Materials Production Center

Air monitoring

FMPC uses dust collectors such as bag collectors, electrostatic precipitators, and scrubbing towers, which remove nearly all of the airborne particulates generated during the many plant operations. The environmental air sampling program provides an indication of the amount of material released into the atmosphere.

Onsite samples were taken at four permanent sampling stations located at the four corners of the production area shown in figure 3. Offsite samples were taken by a mobile unit operated at various distances and directions from the plant determined by local meteorological conditions on the day of sampling. The data for the offsite samples are averaged in groups according to distance from the production area. Concentrations of uranium and total activity of airborne particulates sampled at onsite and offsite locations are given in table 3.

Table 3. Radioactivity levels of airborne particulates January–June 1965

Location	First half 1965		
	Number of samples	Uranium [a] (pCi/m³)	Total activity [b] (pCi/m³)
Onsite			
Southwest	25	0.1	0.5
Northwest	25	0.1	0.3
Northeast	26	0.1	0.5
Southeast	26	0.1	0.3
All onsite samples	102	0.1	0.4
Offsite			
0–2 miles from FMPC	26	0.3	1.5
2–4 miles from FMPC	26	<0.1	0.3
4–8 miles from FMPC	22	<0.1	0.3
8–12 miles from FMPC	8	<0.1	0.2
All offsite samples	82	0.16	0.7

[a] MPC, 2 pCi/m³
[b] MPC, 100 pCi/m³

Water monitoring

Continuous daily samples, collected from the combined sewer leading from the FMPC site to the Great Miami River, are analyzed for uranium and total activity. The combined sewage is composed of treated liquid effluent from the production plants, water treatment plants waste effluent, storm sewer discharge, and treated sanitary sewage. Using the data from the combined sewage samples and stream flow data for the Great Miami River, the FMPC contribution to radioactivity concentrations in the river may be calculated. To check the calculated results, weekly upstream and downstream spot samples are taken at the locations shown in figure 3.

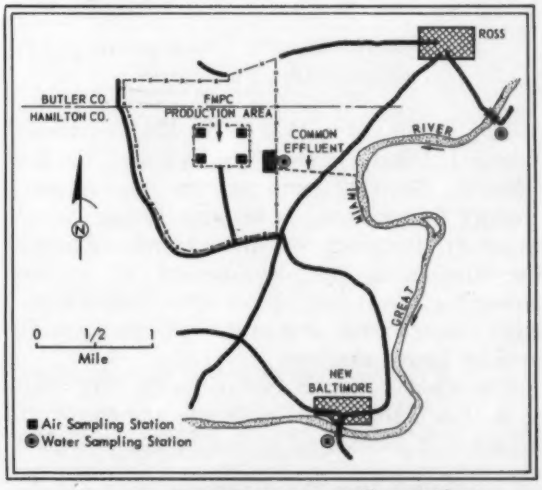

Figure 3. Air and water sampling stations, Feed Materials Production Center

Table 4 presents the calculated and the spot check river concentrations. Since the calculated concentration represents only the contribution from FMPC, it should be compared with the difference of the upstream and downstream measurements.

Table 4. Concentrations of uranium and total activity in the Great Miami River, Ohio, January–June 1965

Location	Method of determination	First half 1965		
		Number of samples	Uranium [a] (pCi/liter)	Total activity [b] (pCi/liter)
Sewer outfall	Calculated from sewer concentrations and stream data (continuous sampling)	181	2	20
Upstream	Spot samples	26	6	70
Downstream	Spot samples	30	9	60
Difference			3	not applicable

[a] MPC, 20,000 pCi/liter
[b] MPC, 3,000 pCi/liter

Recent coverage in *Radiological Health Data:*

Period	Issue
July–December 1960	June 1961
January–June 1961	December 1961
July 1961–June 1962	March 1963
July 1962–December 1963	May 1964
January–June 1964	April 1965
July–December 1964	October 1965

3. Knolls Atomic Power Laboratory January–June 1965[4]

General Electric Company
Schenectady, New York

The principal function of the Knolls Atomic Power Laboratory (KAPL), operated by the General Electric Company for the Atomic Energy Commission, is to support the Naval Reactors Program of the Atomic Energy Commission in the development of atomic power for naval propulsion. This includes design, construction, and prototype operation of nuclear power reactors.

The Knolls Atomic Power Laboratory consists of two sites, the Knolls site and the West Milton site, located as shown in figure 4. The

[4] Summarized from "Knolls Atomic Power Laboratory Semiannual Environmental Monitoring Report, January–June 1965" (Volume 7, Number 1).

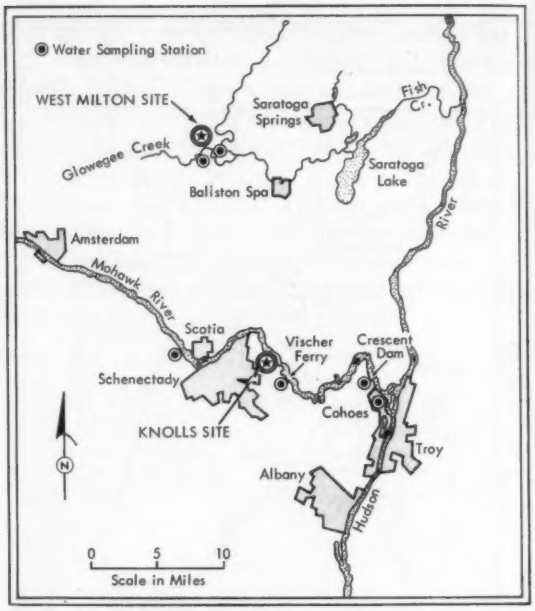

Figure 4. Environmental monitoring locations, KAPL

Knolls site occupies approximately 170 acres on which are located administrative buildings; chemistry, physics, metallurgical, engineering, and radioactive materials laboratories; and critical assembly buildings. The West Milton site occupies approximately 4,000 acres. Its principal facilities include the Triton (S3G) and Bainbridge (D1G) prototype reactors, equipment service building, fuel service building, and waste treatment facility. Regular environmental monitoring activities are conducted to assure that Laboratory releases of radioactivity to the environment are in compliance with AEC standards. The data that follow indicate that Laboratory waste operations have complied with AEC requirements.

Air monitoring

Environmental airborne radioactivity is measured at two locations on the Knolls site, four locations at the West Milton site, and at the General Electric Company Research Laboratory (designated as offsite location) approximately 1 mile west of the Knolls site. Airborne radioactivity is sampled continuously and analyzed on a weekly basis. Measurements of airborne radioactivity are made at least 48 hours after collection allowing the

naturally occurring short-lived materials to decay. The results of the airborne radioactivity analyses are given in table 5.

Table 5. Airborne beta activity, KAPL January–June 1965

Sampling locations	Concentrations (pCi/m^3)
Knolls site	0.24
West Milton site	0.25
Offsite (Research Laboratory)	0.24

In addition to the environmental airborne radioactivity monitoring, surveys are made semiannually of the radiation levels at the perimeter of KAPL at both the West Milton and Knolls Sites. The perimeter survey of June 1965 showed normal background radiation levels for the geographic location.

Liquid waste monitoring

The dilution potential of the Mohawk River is utilized to a limited degree in the disposal of liquid radioactive wastes from the Knolls site. All potential sources of liquid radioactive waste at the Knolls site are connected by control drains to collection tanks in the radioactive waste processing building. The release of liquid waste to the Mohawk River is regulated according to the concentration of fission products in the collection tanks, and the flow of the river. A continuous proportional sample of the Knolls site combined sewer effluent is taken at the point of discharge to the Mohawk River. Radiochemical analyses of weekly composite samples show that strontium–90 is the principal component to be considered in control. The amounts and the radionuclide content of the combined sewer effluent discharged from the Knolls site have been summarized in table 6.

Table 6. Radionuclide concentrations in the Knolls site waste effluent, January–June 1965

Radionuclides	Concentrations (pCi/liter)	AEC Standards (pCi/liter)
Strontium-89	<7.3	3,000
Strontium-90	240	300
Ruthenium-106	<7.3	10,000
Iodine-131	<7.3	300
Cesium-137	410	20,000
Cerium-praseodymium-144	58	10,000

A total of 195 millicuries of beta–gamma activity was discharged to the Mohawk River during the 6-month period at monthly average concentrations ranging from 140 to 1,300 pCi/liter.

Since Glowegee Creek does not have a reliable dilution potential, the radioactivity levels in the liquid waste from the West Milton site are operationally controlled and diluted prior to release to the creek. A total of 3.55 millicuries was discharged at two points into Glowegee Creek during the 6-month period at monthly average concentrations ranging from 8 to 790 pCi/liter. Samples of the Glowegee Creek water are taken once a week at two locations, one at about 150 feet above the point where the S3G effluent enters the stream, and the other 2,640 feet below the S3G discharge or 1,500 feet below the D1G discharge.

Mohawk River water is sampled continuously at the point of discharge from the Knolls site; at the General Electric Company powerhouse 8 miles upstream from the site; at the Vischer Ferry powerhouse approximately 2 miles downstream; and at the City of Cohoes pumping station about 13 miles downstream. Results are given in table 7.

Table 7. Gross beta-gamma activity in streams receiving effluents, January–June 1965

Streams and sampling locations	Concentrations (pCi/liter)
Mohawk River (Knolls site): [a]	
G.E. Powerhouse (upstream)	6
Vischer Ferry (downstream)	7
Cohoes (downstream) raw water	8
Cohoes (downstream) finished drinking water	7
Glowegee Creek (West Milton site): [a]	
Upstream	12
Downstream	13

[a] MPC— 100 pCi/liter

Recent coverage in *Radiological Health Data:*

Period	Issue
Third and fourth quarters 1960	September 1961
First and second quarters 1961	March 1962
July 1961–June 1962	July 1963
July 1962–December 1963	June 1964
January–June 1964	April 1965
July–December 1964	October 1965

4. S1C Prototype Reactor Facility January–June 1965[5]

Combustion Engineering, Inc.
Windsor, Connecticut

The S1C Prototype is a land-based nuclear submarine power plant operated for the Atomic Energy Commission by the Naval Reactors Division of Combustion Engineering, Inc. The prototype contains a pressurized water reactor power plant which is used to conduct research and development work and to train personnel in the operation of naval reactor power plants. Reactor power operations at the S1C prototype facility began in December 1959.

The low-level radioactive waste discharged intermittently from S1C Prototype operations consists mainly of water. Small quantities of airborne particulates in gaseous waste are also generated and released on occasion in the ventilation exhaust air.

Essentially, all of the radioactive waste originates from the activation of minute amounts of impurities in corrosion products in the circulating water used as a reactor coolant. Small quantities of gaseous waste result from the activation of minute amounts of air dissolved in the coolant water.

All materials released to the environment are routinely monitored to assure that waste disposal operations comply with AEC regulations. Monitoring results which follow indicate that the facility has fully complied with the prescribed standards of the AEC.

Air monitoring

Ventilation air from the submarine hull and the supporting facility at the prototype site may, at times, contain small amounts of airborne radioactive particulate or gaseous activities. This ventilation air is discharged to the environment through an exhaust stack. The ventilation air is continuously monitored for radioactivity by particulate and gaseous counters which control the discharge of the air. Alarms are sounded if the concentration approaches permissible limits. When these limits are exceeded, the exhaust air is discharged through a high-efficiency filter bank or the ventilation system is completely shut down and the hull sealed. In addition, air is sampled for particulates at several locations on and offsite. Table 8 presents the average gross beta activities in air.

Table 8. Gross beta activity in air, S1C, January–June 1965

Sampling locations	Average concentrations (pCi/m^3)
Stack and hull effluent	59
Onsite samples	0.35
Offsite samples	0.44

Water monitoring

Liquid wastes are collected in 5,000 gallon retention tanks. When a tank is full, it is sampled and analyzed for its radioactivity content. If the activity is below the allowable discharge limit, the tank contents are released into the industrial waste system. If the limit is exceeded, the contents are diluted below acceptable limits in a 25,000 gallon dilution tank and then released. Table 9 is a summary of the gross radioactivity released to the Farmington River.

Table 9. Radioactivity in liquid wastes discharged into the Farmington River, S1C, January–June 1965

Activity	Quantity
Total beta activity (millicuries)	11.6
Average concentrations (pCi/liter)	
Gross beta	3,500
Cobalt-60	2,800
Iron-59	72
Manganese-54, cobalt-58	490

The Farmington River is sampled periodically at various locations as shown in figure 5 for determination of gross beta activity in river water and mud. Except for one sample taken at the storm drainage waste outlet (sampling location 3) which read 80 pCi/liter, all water samples were less than the detectable level of 10 pCi/liter. All mud samples contained less than the detectable levels of 10 pCi/g.

[5] Summarized from "S1C Prototype Reactor Facility Environmental Monitoring Report, January 1 to June 30, 1965" (CENRD–3163–RS–516).

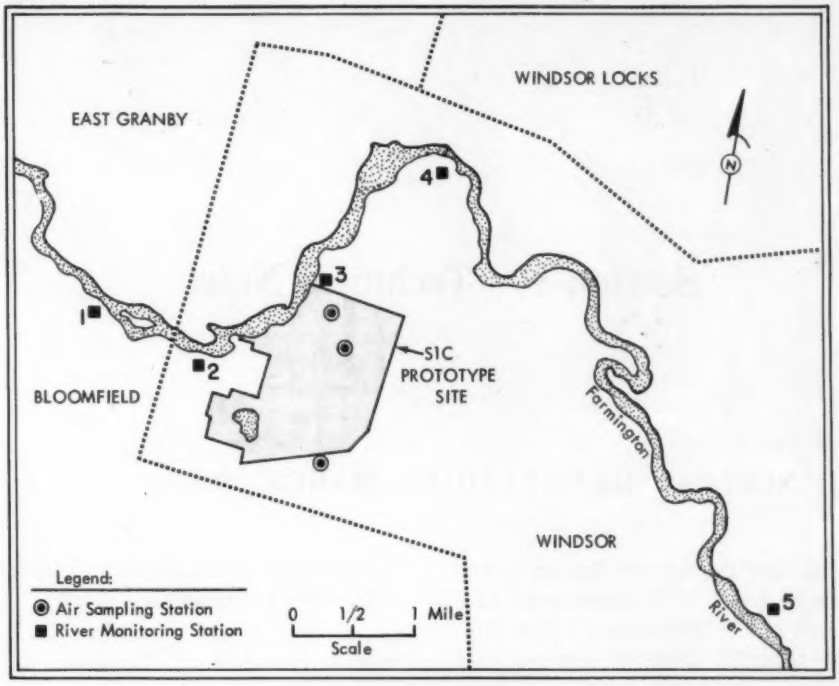

Figure 5. Environmental monitoring locations, S1C Prototype site

Recent coverage in *Radiological Health Data:*

Period	Issue
January–June 1961	March 1962
July 1961–June 1962	July 1963
July 1962–December 1963	June 1964
January–June 1964	April 1965
July–December 1964	October 1965

Section V. Technical Notes

REPORTED NUCLEAR DETONATIONS, MARCH 1966

During March 1966, the Atomic Energy Commission announced five U.S. nuclear tests, one of which was part of the "Plowshare" Program for developing peaceful uses of nuclear explosives. The Commission also announced that on March 20, 1966, the United States recorded seismic signals from the Soviet nuclear testing area in the semipalatinsk region. These seismic signals were equivalent to those of a nuclear test in the low-intermediate to intermediate yield range.

A summary of the announced information on the U.S. tests is presented below.

Date	Testing area	Type of test	Yield [a]
March 5	Nevada test site	Underground	Low
7	Nevada test site	Underground	Low
12	Nevada test site	Underground	Low
18	Nevada test site	Underground	Low-intermediate
24	Nevada test site	Underground (Plowshare)	Low

[a] Low yield is defined as equivalent to the force of less than 20 kilotons of TNT; low-intermediate yield means an equivalent explosive force in the range of 20 to 200 kilotons of TNT; intermediate yield is equivalent to 200 kilotons to 1 megaton of TNT.

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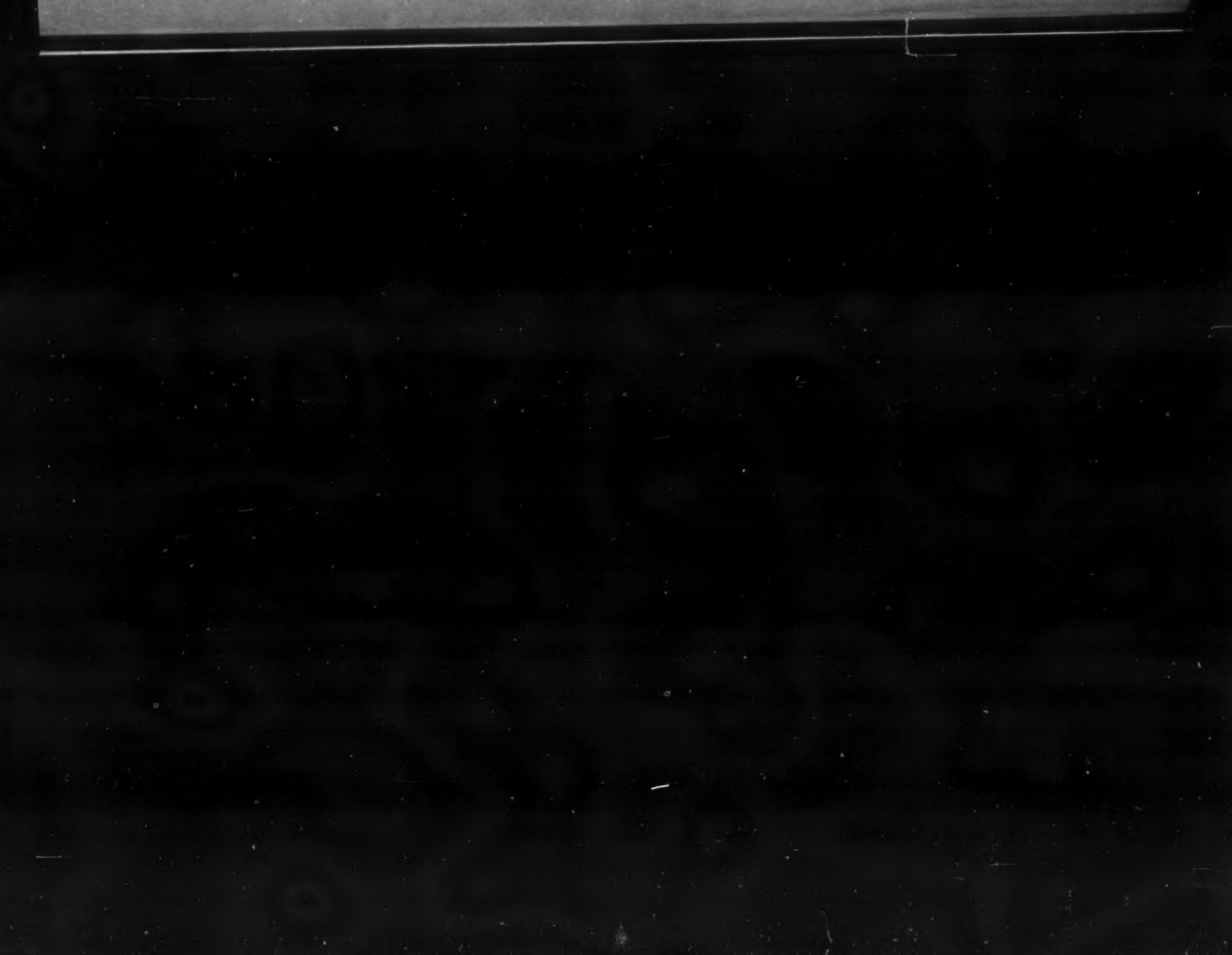

SYMBOLS, UNITS, AND EQUIVALENTS

Symbols	Units	Equivalents
BeV	billion electron volts	equals GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volts	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi per square meter (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi per square mile
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs per gram

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr' a
10^{9}	giga	G	jĭ' ga
10^{6}	mega	M	mĕg' a
10^{3}	kilo	k	kĭl' o
10^{2}	hecto	h	hĕk' to
10	deka	da	dĕk' a
10^{-1}	deci	d	dĕs' i
10^{-2}	centi	c	sĕn' ti
10^{-3}	milli	m	mĭl' i
10^{-6}	micro	μ	mi' kro
10^{-9}	nano	n	năn' o
10^{-12}	pico	p	pē' co
10^{-15}	femto	f	fĕm' to

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